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ABSTRACT

An in-depth study of public housing in New York focuses almost exclusively upon the cost analysis aspect of decision. The costs of various construction techniques, design arrangements, and materials have been collected and analyzed. The stated aim of the report is to reduce cost as much as possible, with user comfort being a secondary consideration. In the light of this aim, basic plan designs are examined in terms of space and subsequent cost efficiency. The means for achieving the spatial arrangements recommended are examined from all aspects. Beginning with structure, comparisons are made between various systems. Interior elements, exterior elements, and mechanical equipment are similarly analyzed. Final recommendations are made for immediate solutions and long term considerations. An appendix contains indexes enabling the cost criteria to be extended to other areas. (RS)

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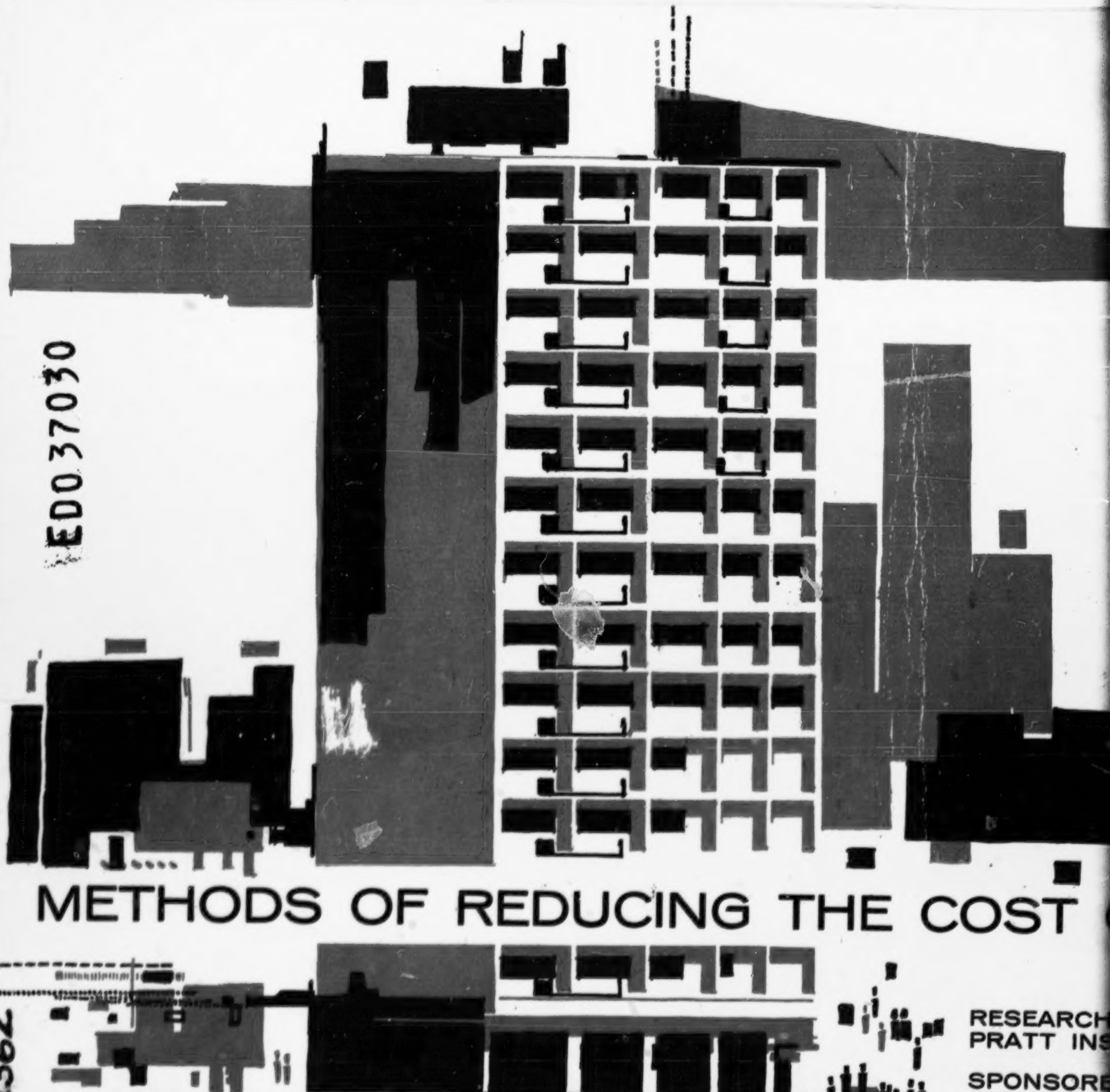

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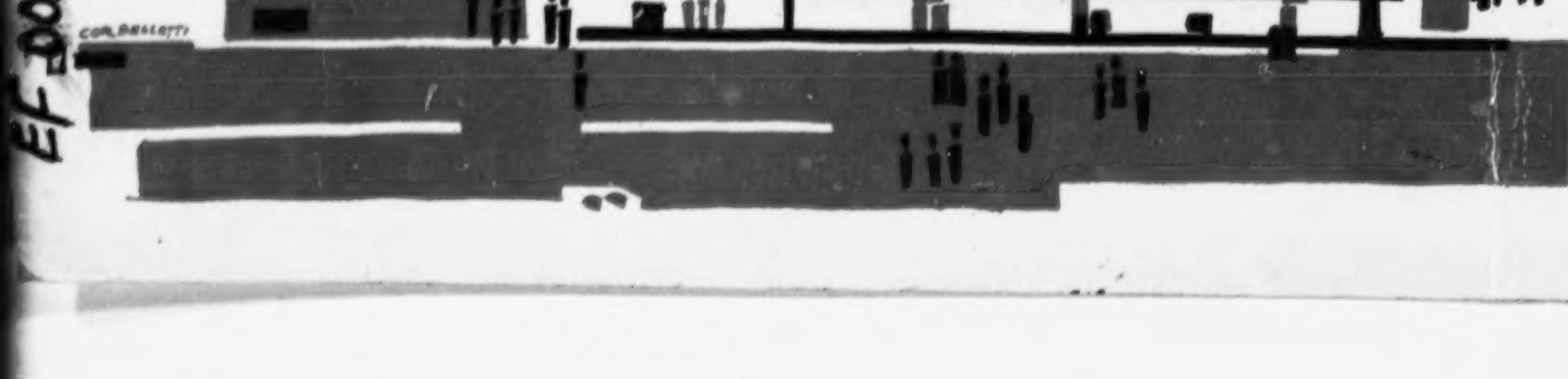
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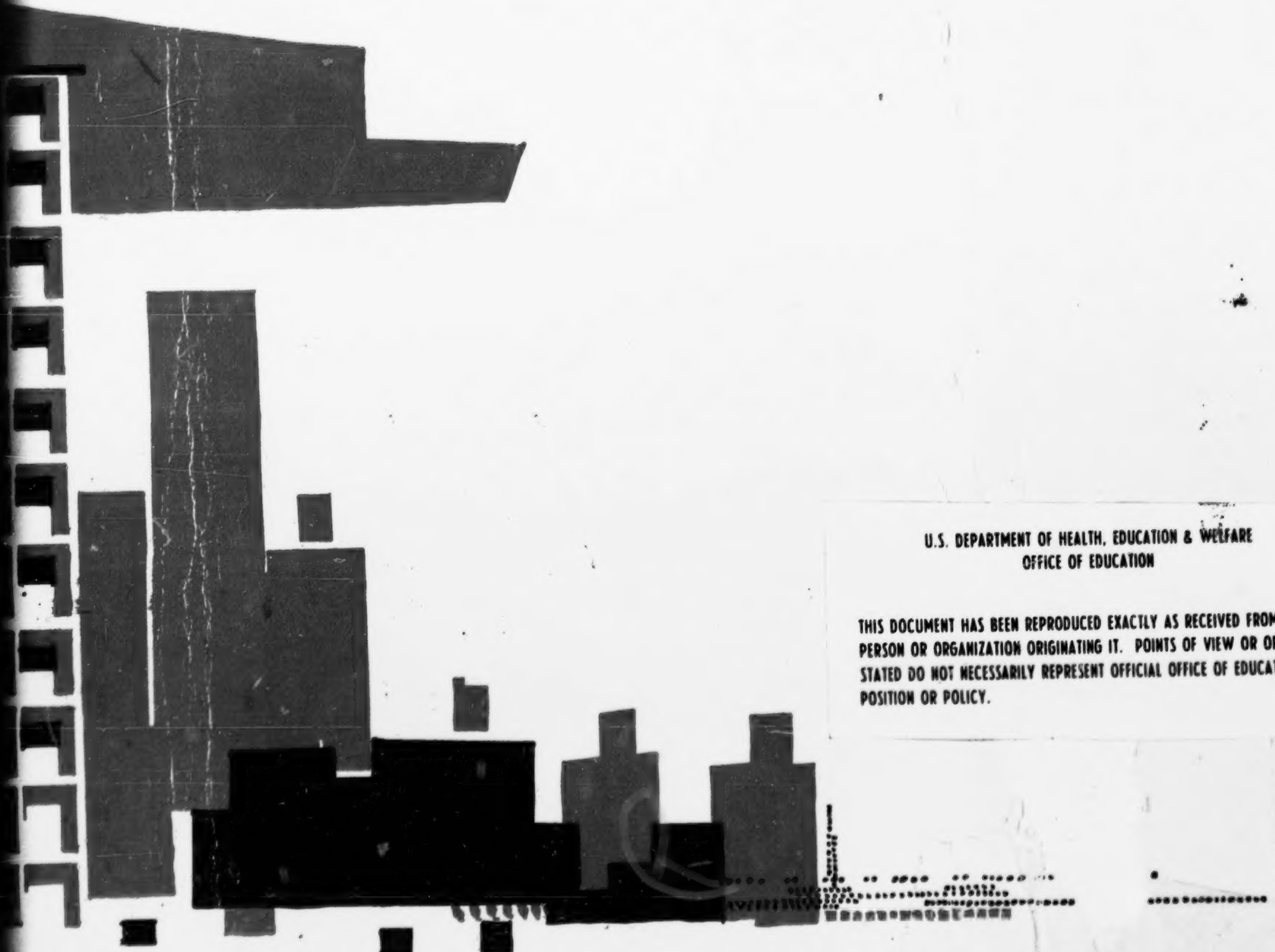

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THE COST OF PUBLIC HOUSING

RESEARCH REPORT OF THE SCHOOL OF ARCHITECTURE
PRATT INSTITUTE BROOKLYN, NEW YORK

SPONSORED BY THE NEW YORK STATE DIVISION OF HOUSING
NEW YORK, N.Y.

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Revised Edition, July 1960

PREFACE

The reduction of building costs is a most worthy and pertinent continuing goal set for itself by the New York State Division of Housing. Every economy achieved reduces the amount of public subsidy and lightens the tax burden required for low-income housing. Each single economy, though small, multiplied by the number of units, stories of buildings, buildings themselves, and projects, can become of such magnitude as to equal the cost of many apartments, and even of buildings.

The School of Architecture at Pratt Institute is most grateful for the opportunity of participating in this study by means of a research grant made available by the New York State Division of Housing. Expert guidance and assistance have combined in this book with persevering academic dedication to offer many provocative and practical contributions for the reader's evaluation. Much more that was learned can not be included for lack of space.

Ready and willing assistance for this research project was found among architects, engineers, builders, and manufacturers, as well as in the research department of the New York State Division of Housing headed by Joshua D. Lowenfish. Professor John H. Callender directed this research for the Faculty. He was ably assisted throughout the research work by Giles Aureli. With a team of graduate students, they devoted one year to this study.

Special acknowledgement is due the Dow Chemical Company for making this publication possible, by means of a generous grant.

This is a never ending study, because new materials and methods continue to influence costs. At Pratt Institute a test shed has been built, with funds made available by the New York State Division of Housing, for field testing, under actual winter conditions, various types of exterior walls as proposed in this publication, and as subsequently modified by additional research in respect to comparative cost, efficiency of insulation, and other values. Findings should be valid for other types of construction as well.

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FOREWORD

With the growth of research in practically every field of endeavor steadily gaining momentum, it is good for us to be counted among the participants.

As a result of special budget appropriations by the New York State Legislature, we have been enabled to engage several colleges to do research in the high cost of public housing. The program entailed investigation of new materials, new methods of construction and new concepts in planning. Pratt Institute concentrated its efforts on the first two, and this publication amply demonstrates the extent of the study therein.

The task of the researchers was not lessened by our requirements not to reduce the standards of planning and that of accepted amenities. The work, therefore, naturally led into channels of greater utilization of recent innovations in application of a number of materials of more recent vintage. We are cognizant, however, that not every laboratory solution may find a practical application. There are any number of related factors, such as jurisdictional disputes during construction, and ability of structures to withstand heavy wear and tear during the life of the projects, that may have a bearing on the application of recommended materials or methods of construction.

This study has alerted the architectural and engineering professions, the construction industry and the researchers in academic halls to the realization that a problem exists and that solutions thereto are eagerly sought.

The recommendations of this study do not necessarily reflect the thinking of the technicians of the Division of Housing and the mention of the many construction materials should not be construed as their sponsorship by this office.

James W. Gaynor
Commissioner
New York State Division of Housing

INTRODUCTION

Concerned by the mounting costs of public housing, Joseph P. McMurray, then Commissioner of the New York State Division of Housing, energetically sought ways and means of reducing them. Among other measures taken, Commissioner McMurray, in 1957, invited the School of Architecture of Pratt Institute to undertake a study, at the graduate level, of methods of reducing the cost of public housing. The invitation was accompanied by a grant of funds.

Pratt Institute welcomed the opportunity to undertake this work, not only as a public service to the community of which it is a part, but also as a valúable addition to its educational program. The study was carried out by a small group of graduate students (six in the first term, seven in the second term of the 1957-1958 school year), under the direction of Professor John H. Callender, as part of their work for the degree of Master of Architecture.

James W. Gaynor, the present Commissioner of the New York State Division of Housing, shared his predecessor's interest in the objectives of the study and continued its support. With this, the School of Architecture completed the research work — this time with the additional objective of publishing it. This objective was made possible in 1959 by a special grant from Dow Chemical Company of Midland, Michigan.

The scope of the study, as defined in the program drawn up by the research group and approved by the State Division of Housing, was limited to low-rent public housing in the most urbanized boroughs (Manhattan, Brooklyn, Bronx) of New York City. It was therefore concerned with typically high-cost sites, resulting in high-density projects, employing high-rise buildings. Site selection, community planning, and site planning were excluded from consideration in the present study, which is concentrated on investigation of the economies of layout, design, and construction of the buildings themselves.

The unique feature of the present study is its exclusive emphasis on cost. Architectural students are often permitted freedom of design without the practical restraint of costs. But in this project, a design which is superior to the presently accepted design, but costs more, must be considered a failure. A successful solution is one which at least equals the present design in quality, but costs less. For the purpose of this study, cost is defined as the total cost during the fifty-year life assumed for the buildings. It thus includes not only the first cost, but maintenance and operating costs over a fifty-year period. A new design which reduces the first cost, but increases the maintenance cost, may prove more expensive in the long run. On the other hand, a design, technique, or material which actually costs more at first, may so reduce maintenance costs as to prove more economical ultimately.

Cost being the main criterion in this study, it was obviously necessary to obtain the most accurate, up-to-date cost figures possible. Those with experience in the building industry know that there is no more difficult task and that there is nothing more elusive than accurate, dependable figures on building costs. Nevertheless, cost figures had to be obtained and every effort was made to make them as accurate as possible. Current public housing costs were obtained from the State Division of Housing, the City Housing Authority, and from contracting firms bidding on public housing work. Costs of other types of construction were obtained from well-recognized cost authorities such as Seelye, Stevenson, Value and Knecht and H. Nash Babcock, or from contractors in the Metropolitan New York area.

Early in the course of the study, the need for a realistic basis for comparison became evident. At the request of the research staff, the New York State Division of Housing provided complete working drawings, specifications, and budget costs for a typical low-income housing project in New York City, which had just been put out for bids. Actual contract costs for this project became available before the study was completed. Throughout the course of the research, this project was used as the basis for all comparative studies. Statistics concerning this "standard" project are given in Chapter Three.

Costs are given in the report for New York City as of June 1958. Boeckh Building Cost Indices for June 1957, June 1958 and June 1959 have been included in the Appendix. The reader who wishes to translate the costs given in the report into 1959 costs for New York or any of twenty-four other cities, can do so by using the Boeckh indices.

The method of procedure employed in the study was that of elimination. The first step was the listing of every idea that might conceivably produce cost savings. These items were considered one by one and the least promising ones were eliminated. The ideas that remained after the lengthy winnowing-out period, were then subjected to intensive research and study and the results are reported herein.

The final step was the selection, based upon the results of the study, of those ideas to be recommended for adoption. Not all of the items studied proved in the final analysis to save money, and such items were, of course, not recommended. Some items could be easily demonstrated to save money, but it was difficult to prove that they would be acceptable in quality; such items were recommended with reservations. Any proposal which clearly equalled the present item in quality and was shown to cost less, was recommended. In some categories several ideas thus qualify for recommendation; it was not considered necessary to pick the best of these and recommend only that one. Recommendations are divided into those which can be put into effect immediately and those which require a change in the building code or other laws,

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or regulations, and thus cannot be used immediately. The latter are recommended for consideration by the Division of Housing in the near future.

It should be noted that the first Chapter of the report, that on "Plan Studies," deals with a subject that is less amenable to accurate cost analysis than the subjects presented subsequently. This first Chapter is thus on somewhat less firm ground economically than the remainder of the report, and the recommendations derived from it must be qualified accordingly.

The research staff and their faculty adviser wish to acknowledge assistance received from many sources, and to express their gratitude for this help, without which the study could never have been brought to a successful conclusion. Dean Olindo Grossi, Professor William McGuinness, and several members of the faculty of the School of Architecture were frequent contributors of helpful advice. Less expected and therefore more appreciated, were a number of distinguished professional practitioners who gave generously of their valuable time and from their vast experience. Outstanding among these was Albert L. Stevenson of the firm of Seelye, Stevenson, Value, and Knecht, who furnished much of the cost data and gave valuable advice on many of the structural systems which were being studied.

Others who helped in great measure were Edward Schnitzer, Guy Panero, Fred Severud, Sidney Katz, and, up to the time of his untimely death, William Vladeck. More than any one person, Joshua D. Lowenfish, Director of Architectural Research, New York State Division of Housing, gave unstintingly of his time and of his wealth of experience. He patiently complied with all requests, however unreasonable, for data and costs, and helped to guide the study in the proper direction. Finally, as noted at the outset, without the initiative and the financial support furnished by both Commissioner McMurray and Commissioner Gaynor, this study could never have been accomplished.

John Hancock Callender AIA
Associate Professor and Director of Research
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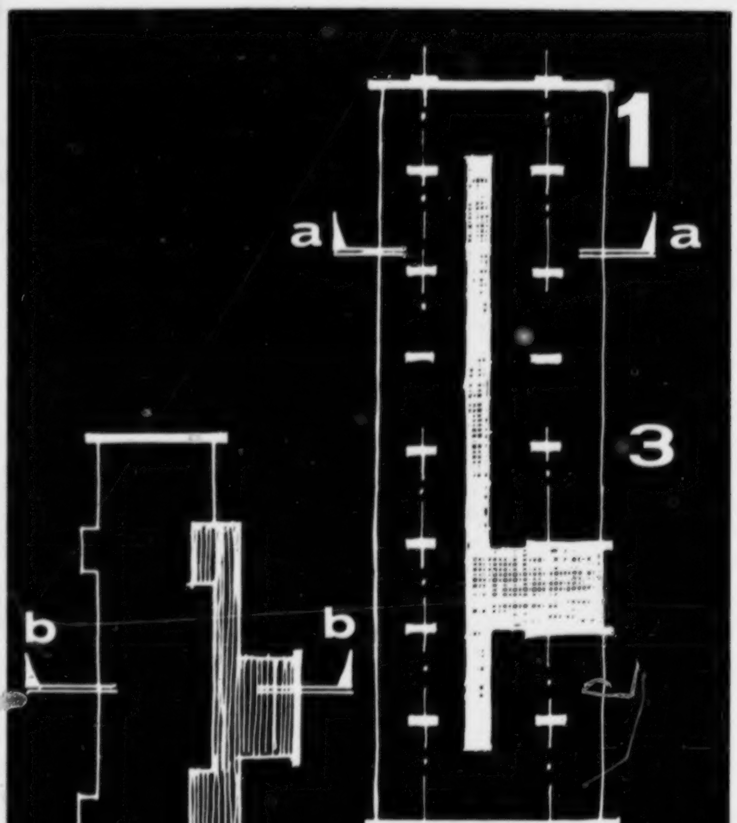
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CHAPTER ONE – PLAN STUDIES

Of the several plan types which were explored for possible economies, three were selected for detailed study and are presented on the following pages. They are:

1. Tower scheme
2. Open-corridor scheme
3. Interior-corridor scheme

None of these plan types can be considered new or radical. All have been used for low or middle-income housing for at least a decade. However, the first two have been rarely used in New York City public housing, while the third is now common, having largely replaced the cross plan which dominated public housing for almost two decades. The third scheme is included here largely as a basis for comparison with the two less familiar schemes.

In each of three plan types the following departures from current New York City public housing practice have been incorporated:

1. Regular column spacing
2. Full distribution of apartment sizes in one building
3. No basement

Regular column spacing is, of course, more economical than irregular spacing and is used as a matter of course for most buildings. However, architects have found it difficult to conform to the rigid planning requirements imposed by the housing agencies without departing from regular column spacing. Flat plate reinforced concrete construction with "spattered" columns solves this problem by permitting the columns to be located in accordance with plan requirements. This type of construction, although more expansive than regular column spacing, is now standard practice in New York City housing work.

In order to re-examine this situation, the three plan types selected for study were all designed with regular column spacing. Required room sizes have been maintained in all cases and the columns, projecting only a few inches, do not seriously impair the use of the living space. On the basis of these examples, it would appear that the economies of regular column spacing could be achieved without sacrifice of livability, if the housing agencies would modify their requirements slightly, and if the architects would employ more ingenuity in planning.

The required distribution of apartment sizes in a housing project has traditionally been achieved by the use of different buildings for the different apartment types. This technique is practical in the large multi-building project which has heretofore been the norm. Recent changes in public housing policy favor more small projects — even one-building projects. With this policy in mind, each of the three schemes presented here has been designed to provide the full range of apartment sizes in a single building, in order to demonstrate that this idea is not only possible but entirely practical.

Basement space often costs more than the equivalent space provided above ground. Where ground conditions are poor, a situation frequently encountered in housing projects, economies can be achieved by omitting basements and providing equivalent space on the first floor. Since the space ordinarily provided in the basement occupies only a fraction of the total floor area of the building, the remainder of the ground floor can be left open to provide covered play spaces and sitting areas. The improved visibility at the ground level which results from this scheme would go far toward mitigating the "walled-in" feeling produced by the long high buildings of the interior-corridor type.

Several other ideas have been tried in one or more of the three schemes presented here. A system of framing employing cantilevered floor slabs with two columns per bay, instead of the usual four, has been used on both the open-corridor and the interior-corridor schemes. This structural system is discussed in detail in Chapter Two; it was used on the two examples in this Chapter in order to demonstrate that it did not present, as had been feared, a serious handicap to architectural planning. The possibility of providing a combined utility and play area midway in the height of the building, has been suggested for the tower scheme. The cost-saving skip-stop elevator system has been employed in the open-corridor scheme. The possibility of using the living room for sleeping, thereby eliminating one bedroom in each apartment, has been explored in the interior-corridor scheme, as has also the use of a "dormitory" bedroom for three or four children. These ideas are discussed further as they are presented in the following pages.

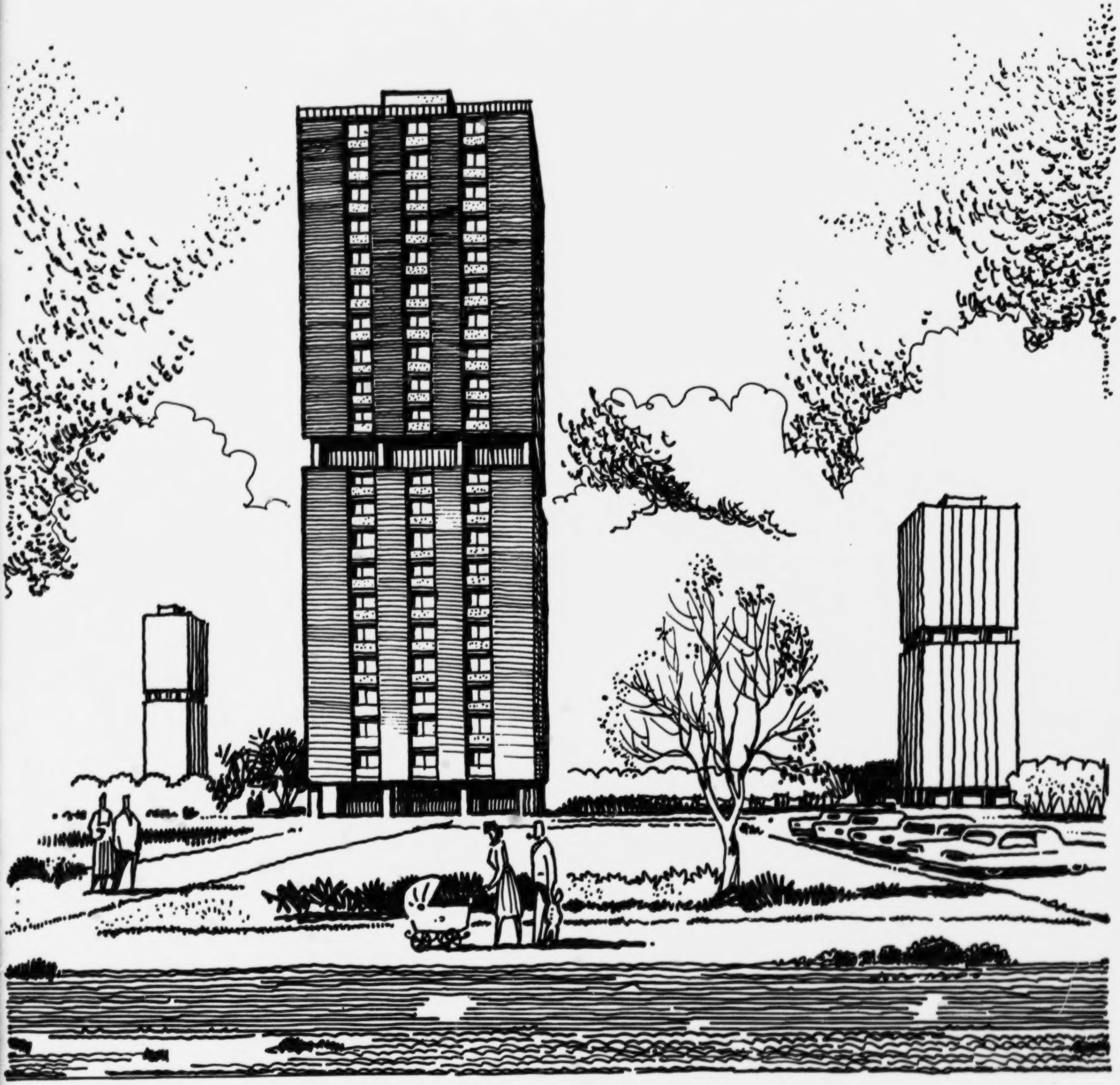
1 TOWER SCHEME

This is the name given to a plan type which is approximately square, with the rooms disposed around all four sides of a central service core. It has been used successfully for middle-income housing in New York and Chicago since the late 1940's. As far as could be ascertained, the tower scheme has not yet been used for low-income housing, probably for the reason discussed below.

The tower scheme has a number of advantages and one serious disadvantage. It is readily apparent that the compact plan results in a minimum of perimeter construction and the shortest possible utility runs, with attendant economies. Even more significant is the reduction in the amount of expensive public corridor space; in the tower scheme the area of public corridor per construction room is about half that in the interior-corridor scheme, and public corridor space is relatively expensive as will be shown in Chapter Four.

In most cases, the tower plan provides cross-ventilation and two exposures for each apartment, a very desirable arrangement as far as livability is concerned. The tower scheme also offers advantages in site-planning. The square plan is easy to dispose, even on an irregular site, and when used in large projects, it results in a greater feeling of openness on the site than occurs when long narrow buildings are used.

A serious economic handicap to the tower scheme is the high cost of elevators. Providing only four to six apartments per floor, as compared to ten to twelve apartments per floor in the interior-corridor scheme, the cost of elevators per dwelling unit is thus two to two and one-half times higher in the tower scheme. For this higher cost, greatly improved livability is provided. This scheme is presented here in the belief that the economies noted in the paragraphs above will offset the higher cost of the service core, thus affording improved livability at no increase in cost.



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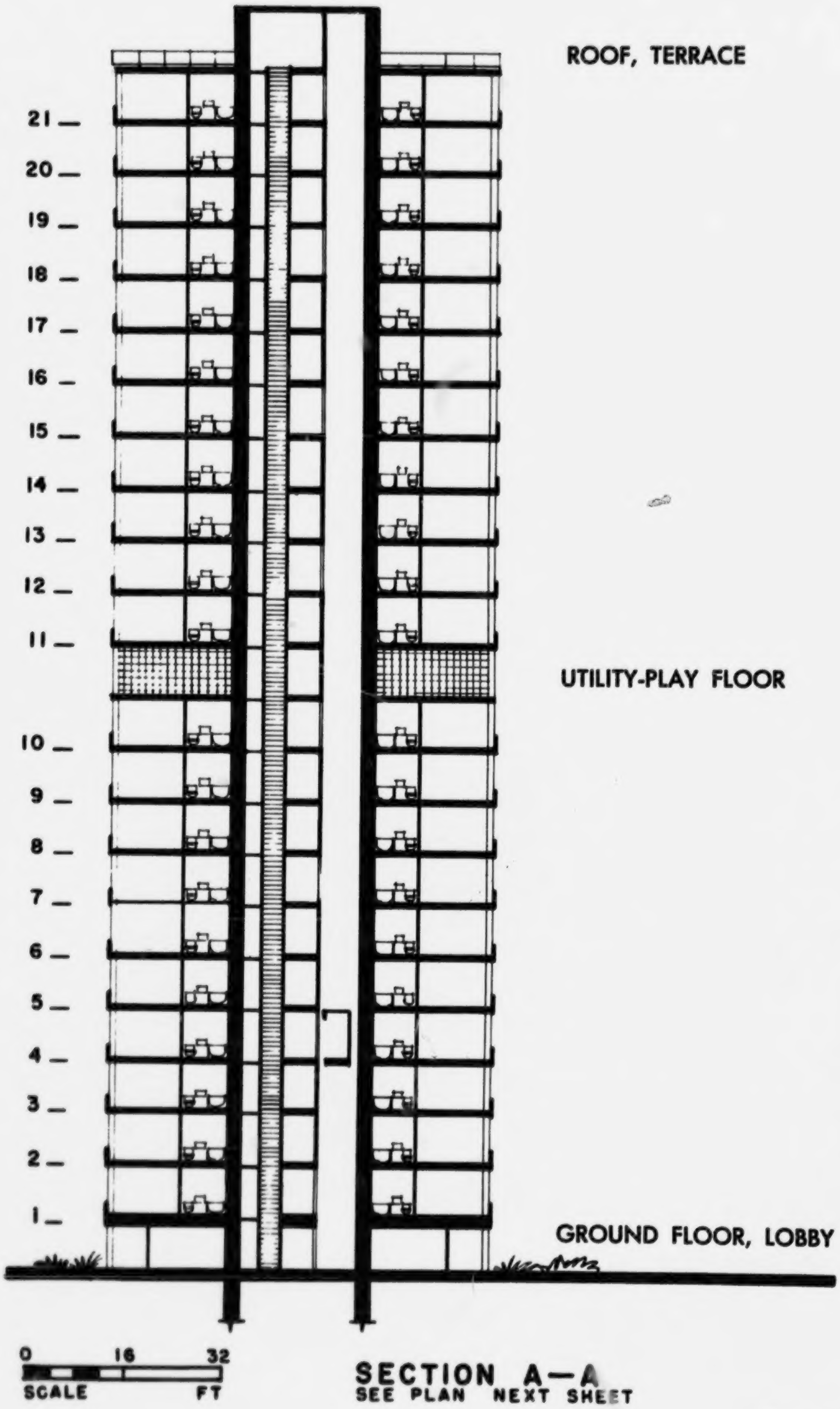
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SECTION A—A
SEE PLAN NEXT SHEET

Cross-section through Tower Building

The required distribution of apartment types is provided in one building by means of the use of five different floor plans, which are detailed on the following pages. The distribution is shown in the following schedule:

Floor plan	Number of uses	Apartment types (by construction rooms)						Total
		2	3	4	5	6	7	
A	10	—	—	—	40	—	—	40
B	2	2	6	—	4	—	—	12
C	4	—	—	8	—	8	—	16
D	1	—	2	—	—	—	2	4
E	4	—	8	16	—	—	—	24
Total	21	2	16	24	44	8	2	96
Distribution by %		**2.1**	**16.7**	**25.0**	**45.8**	**8.3**	**2.1**	**100.0**
Required distribution		**3.5**	**16.5**	**25.0**	**45.0**	**8.5**	**1.5**	**100.0**

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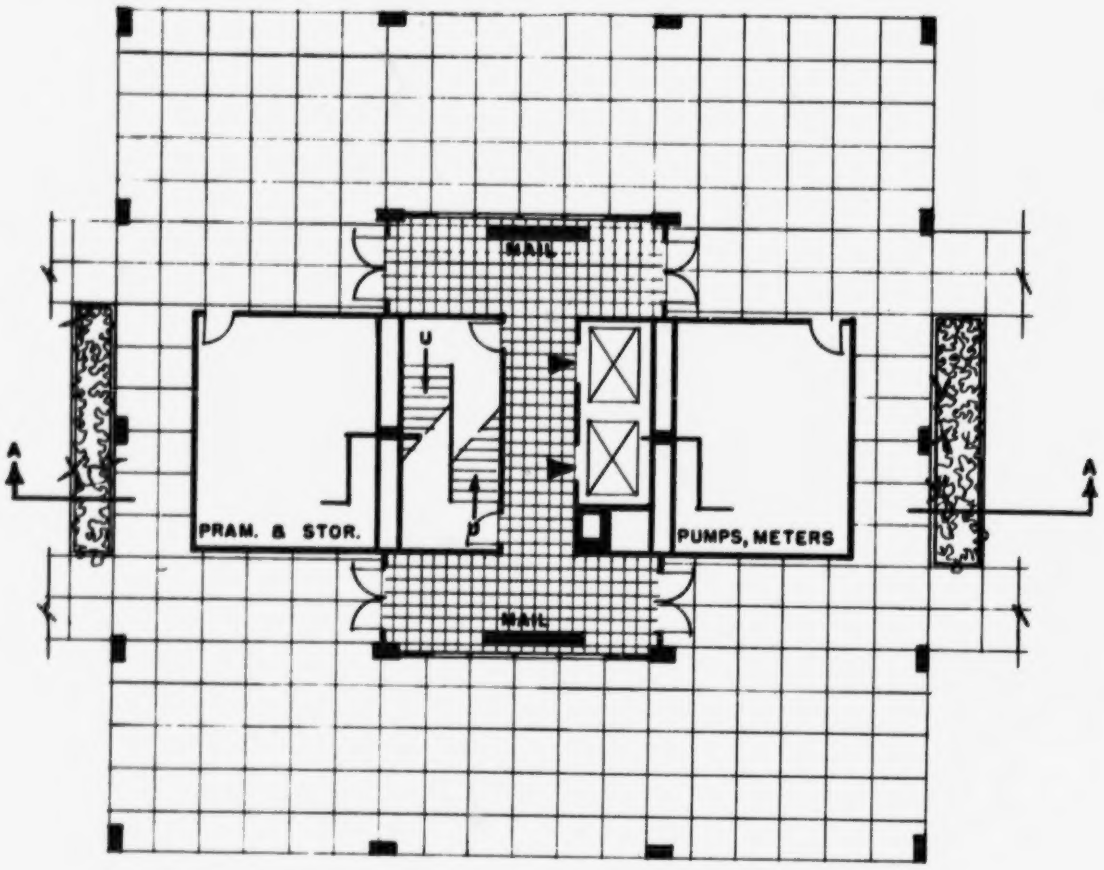
There are a total of 430 construction rooms, or 478 rental rooms, for an estimated average occupancy of 502 people. For the twenty-one floors the average gross area per construction room is 206 square feet, and the average length of the exterior wall per construction room is 12.7 feet.

LOBBY

In addition to the twenty-one floors of apartments there are two non-dwelling floors — the ground floor and the utility-play floor at mid-height — making a total for the building of twenty-three stories. The building is approximately sixty-five feet square.

Cross-section through Tower Building



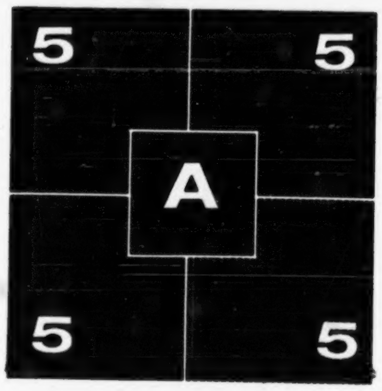
LOBBY FLOOR PLAN

LOBBY FLOOR PLAN

The building has in effect been raised one story, bringing the usual basement to ground level. This greatly reduces the amount of expensive foundation wall required, and provides useful covered outdoor space and pleasant ground-level vistas.

Laundry and tenant storage facilities, usually located in the basement, have been placed on a non-dwelling floor at mid-height of the building. The remainder of this floor is used as outdoor play space and sitting area. This suggestion obviously offers no cost saving, but it promises so much in improved livability that it was felt to be worth including here.

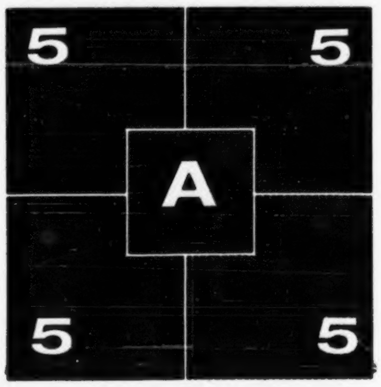
DISTRIBUTION PLAN

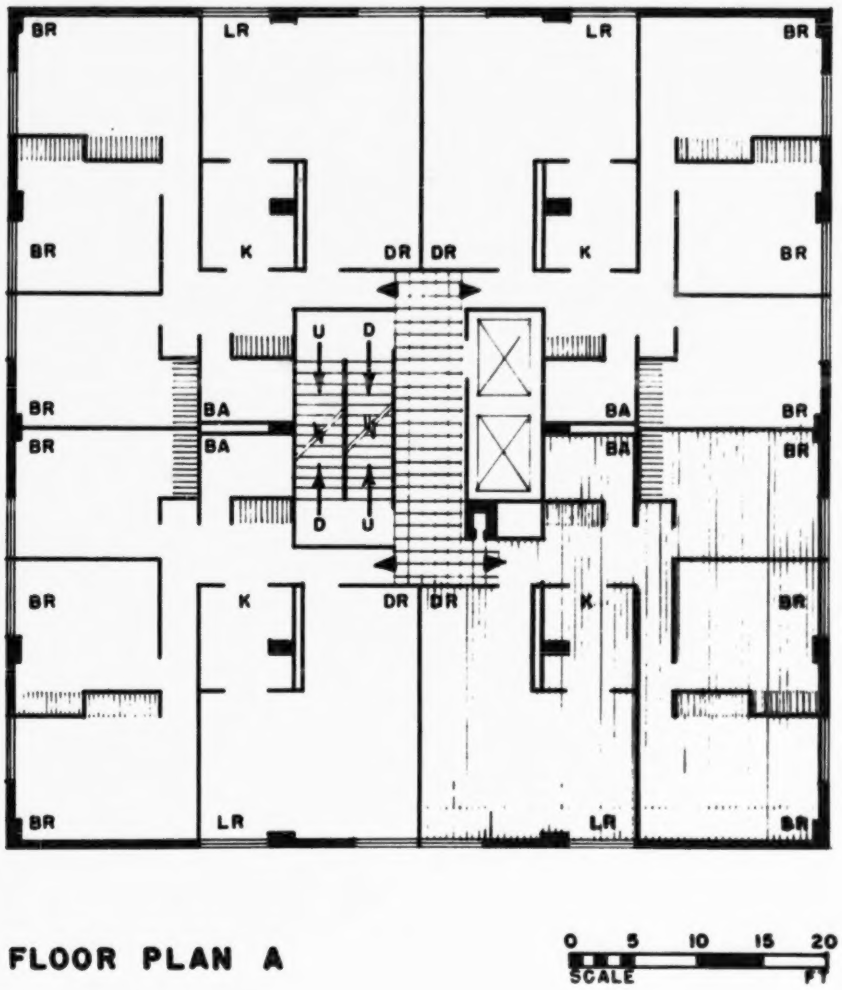


FLOOR PLAN A

Plan A is used ten times and is thus the most nearly typical of the five floor plans. It has four five-room apartments, each having three bedrooms. The total construction room count for the floor is 20. The gross floor area is 4,224 square feet, or 211 gross square feet per construction room. Each apartment has cross-ventilation and exposure in two directions.

DISTRIBUTION PLAN

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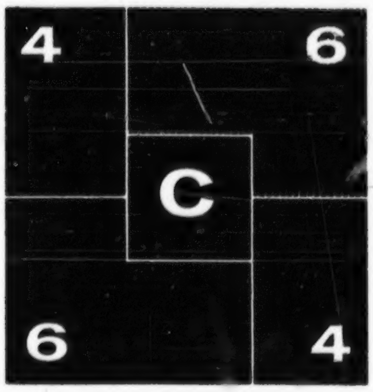
FLOOR PLAN A

FLOOR PLAN B

Plan B occurs on only two floors of the building. It has two five-room apartments (three bedrooms), three three-room apartments (one bedroom) and one efficiency apartment (no bedroom). In all there are 21 construction rooms per floor and the gross floor area per construction room is 201 square feet. The four corner apartments have cross-ventilation and two exposures. The efficiency apartment and one of the three-room apartments have only one exposure.



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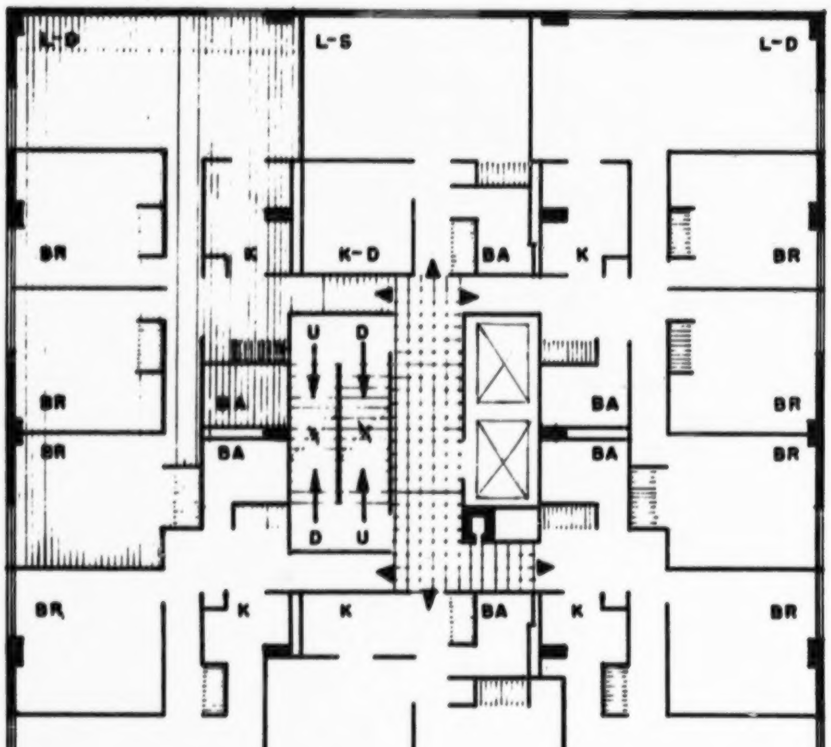
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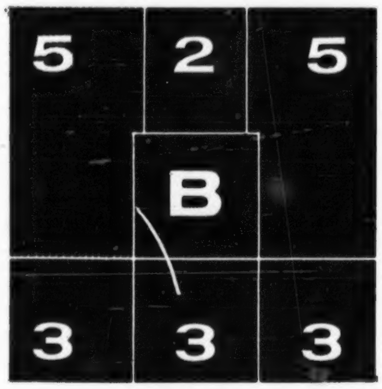
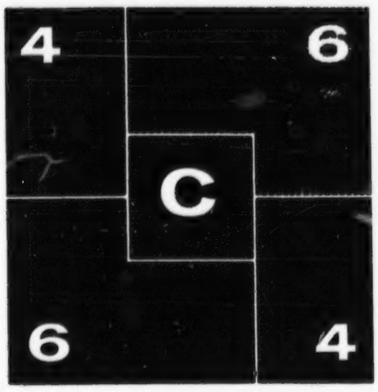
FLOOR PLAN B

DISTRIBUTION PLAN



TOWER SCHEME



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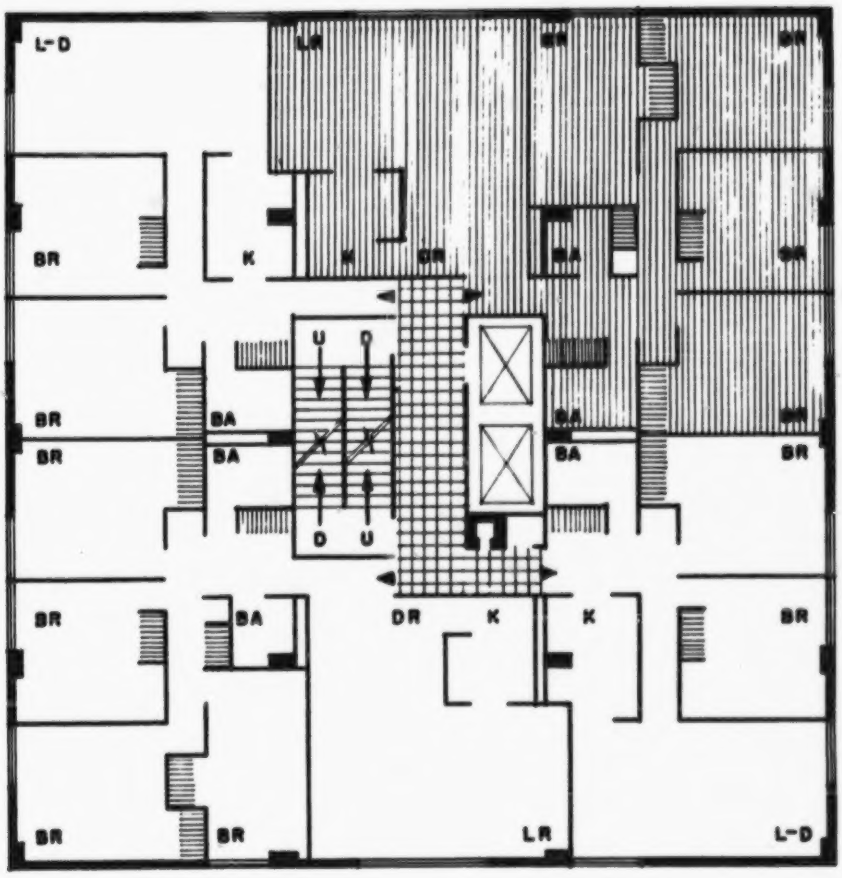
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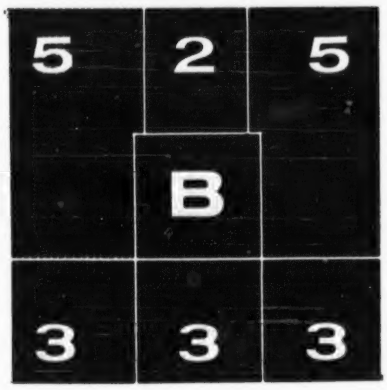
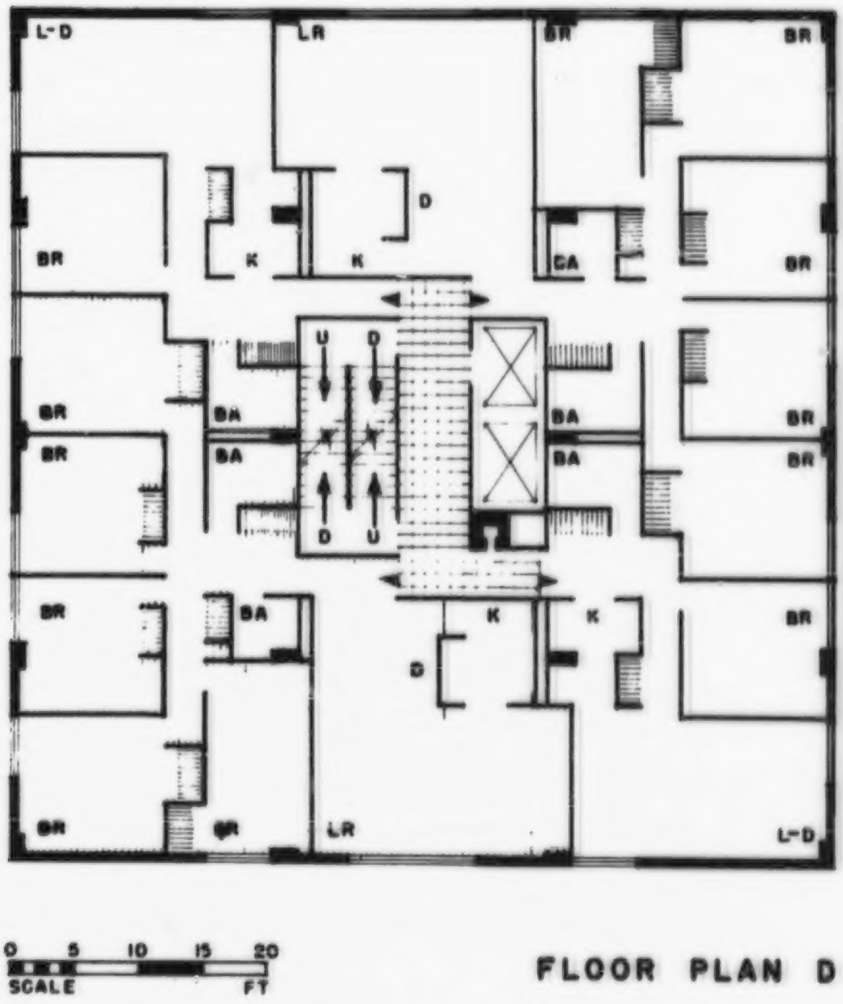
FLOOR PLAN C

DISTRIBUTION PLAN

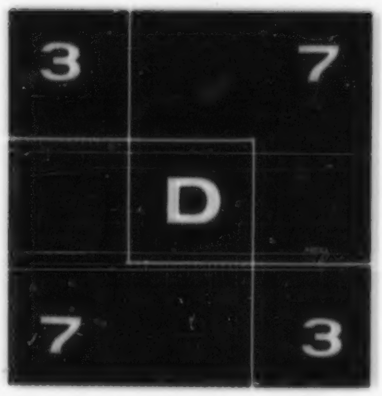


FLOOR PLAN C

Plan C is used on four floors of the building. It consists of two six-room apartments (four bedrooms) and two four-room apartments (two bedrooms). The total construction room count per floor is 20, and the gross floor area per construction room is 211 square feet. Each apartment has cross-ventilation and two exposures.


L-D
LR
BR
BR
BR
D
K
K
BA
BR
BR
BR
BA
BA
BA
BA
BR
BR
BR
BR
BR
BA
K
K
D
BR
BR
BR
LR
L-D
U
D
D
U
0
5
10
15
20
SCALE
FT

FLOOR PLAN D

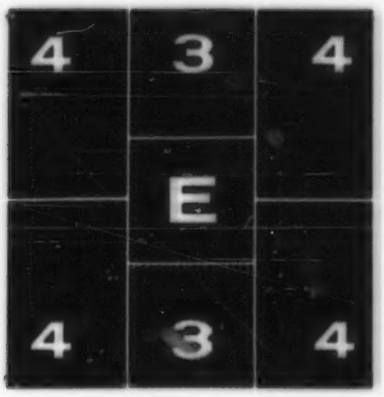


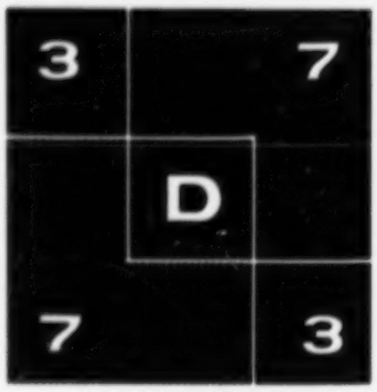
DISTRIBUTION PLAN

FLOOR PLAN D

Plan D occurs only once in the building. It has two seven-room apartments (five bedrooms) and two three-room apartments (one bedroom). There are 20 construction rooms and the gross area per construction room is 211 square feet. Each apartment has cross-ventilation and two exposures.

DISTRIBUTION PLAN





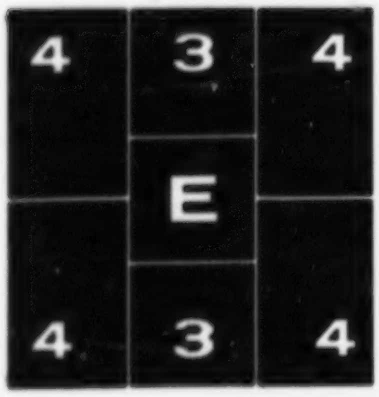
DISTRIBUTION PLAN

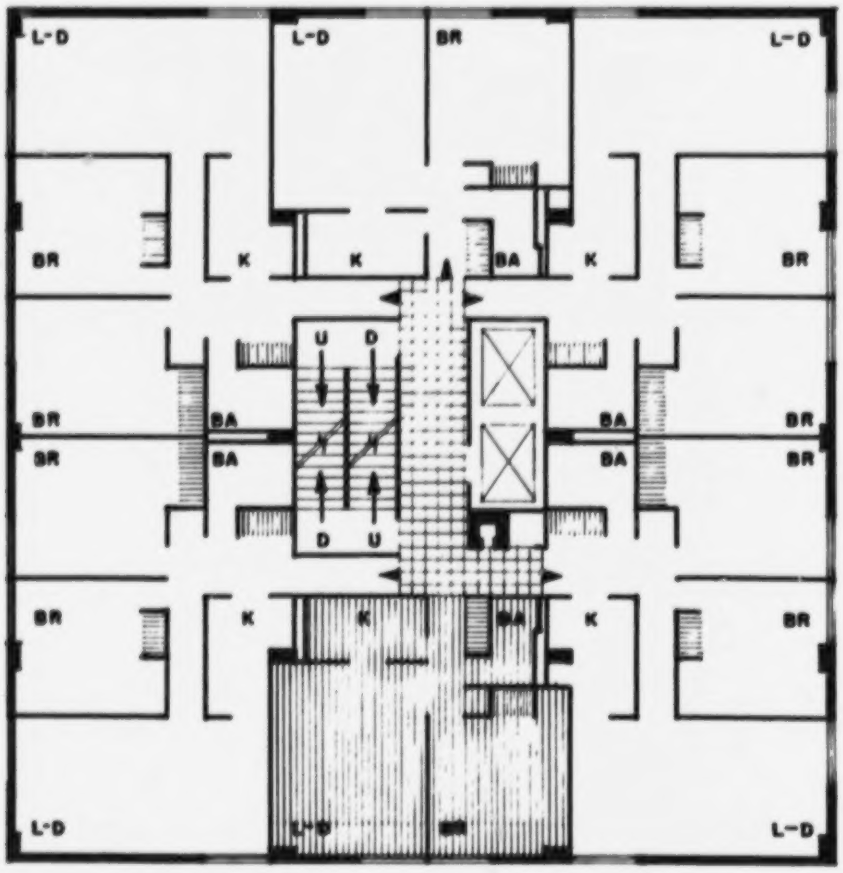
FLOOR PLAN E

Plan E is used on four floors of the building. It consists of four four-room apartments (two bedrooms) and two three-room apartments (one bedroom). The total number of construction rooms per floor is 22 and the gross area per construction room is 192 square feet. The four corner apartments have cross-ventilation and two exposures. The two smaller apartments have only one exposure.

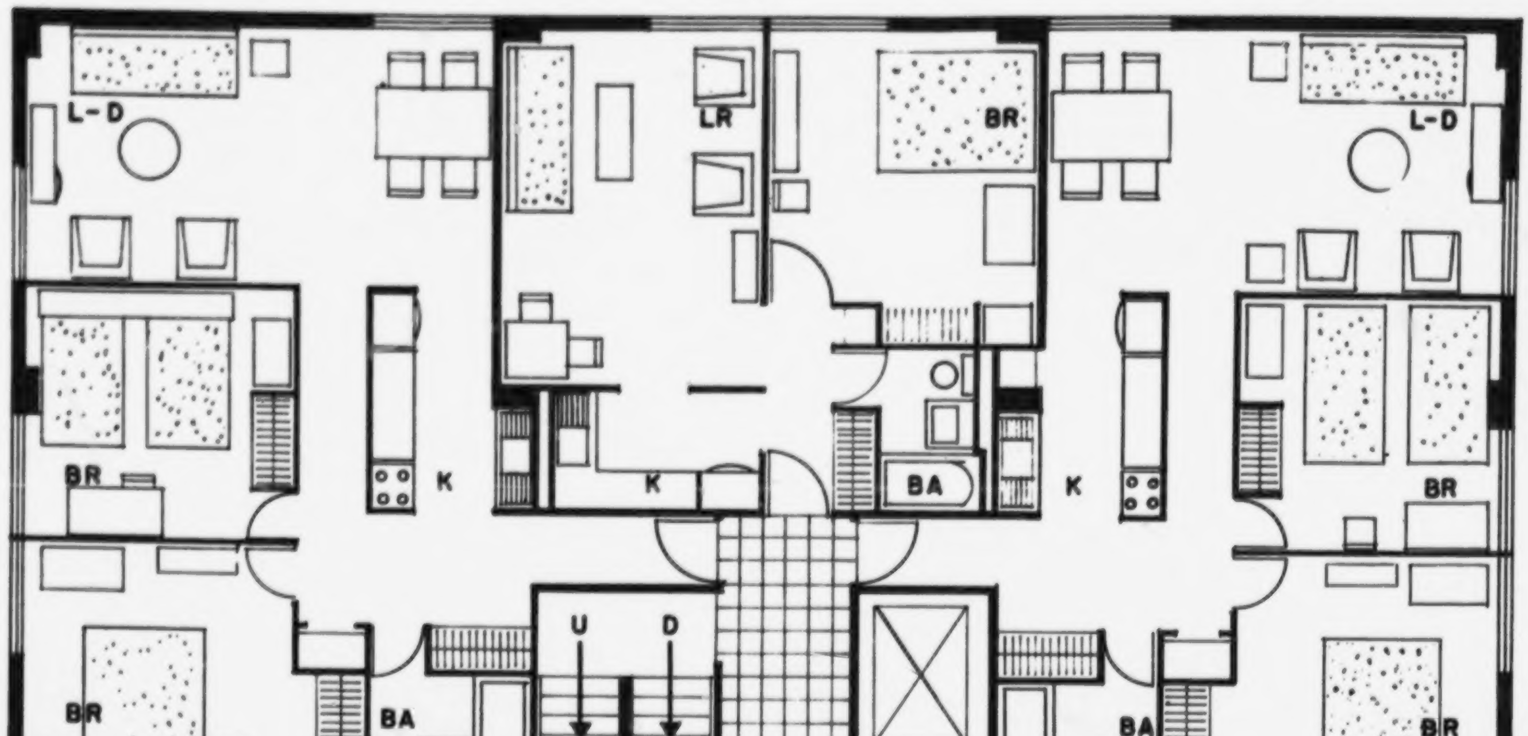
This plan is shown at larger scale and with all furniture indicated on the following page.

DISTRIBUTION PLAN




L-D
L-D
BR
L-D
BR
K
K
BA
K
BR
U
D
BR
BA
BA
BR
BR
BA
BA
BR
D
U
BR
K
K
BA
K
BR
L-D
L-D
BR
L-D
0
5
10
15
20
SCALE
FT

FLOOR PLAN E


L-D
LR
BR
L-D
BR
K
K
BA
K
BR
U
D
BR
BA
BA
BR
BR
BA
BA
BR
D
U
BR
K
K
BA
K
BR
L-D
LR
BR
L-D

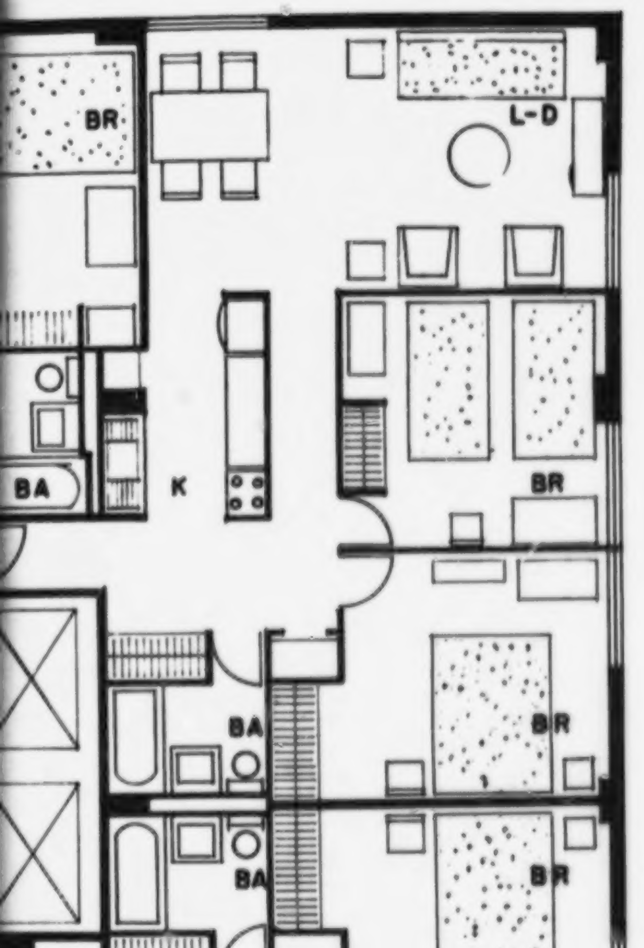
FLOOR PLAN E TOWER SCHEME

0
5
10
SCALE
FT

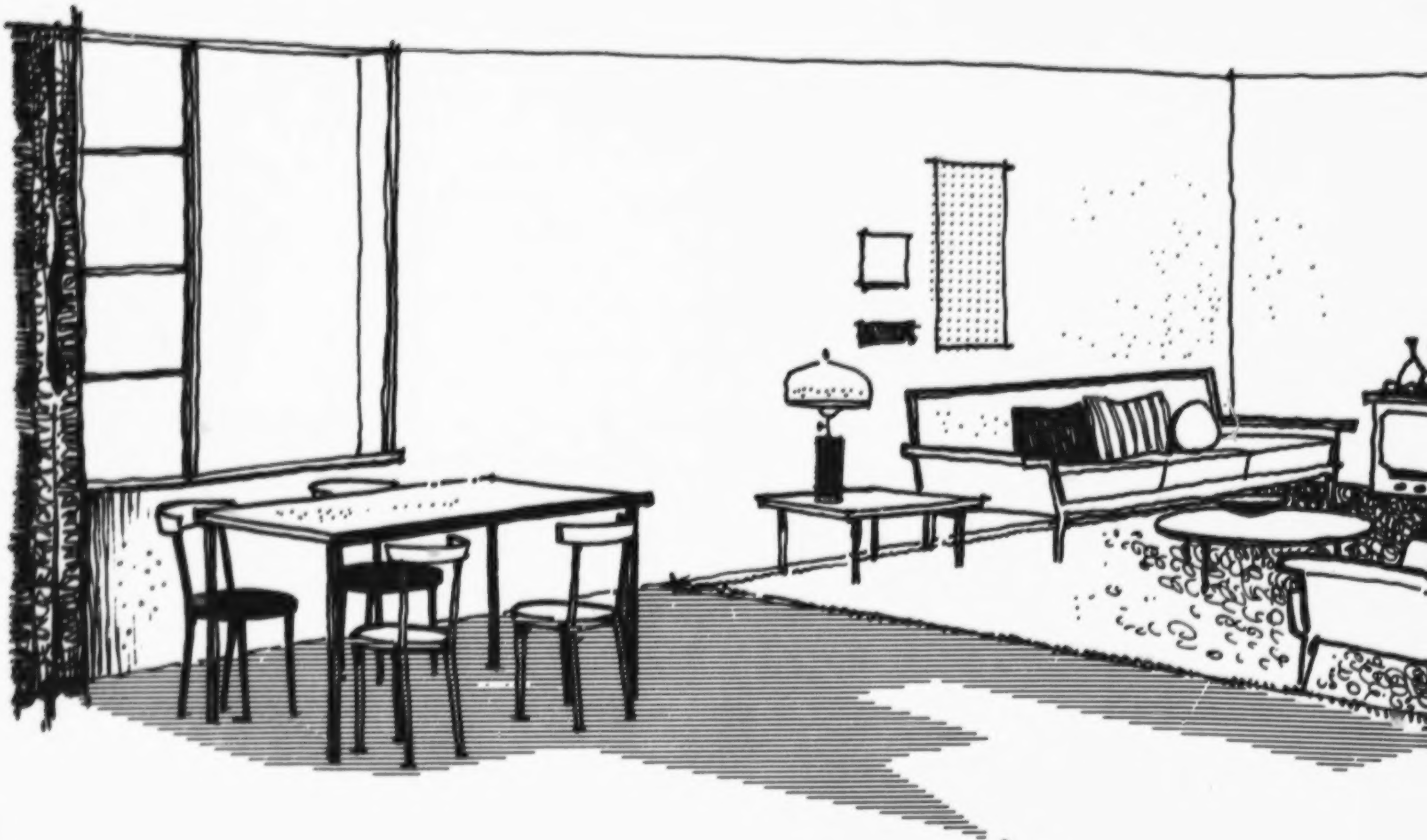
TOWER SCHEME

The plan shown on the previous page is shown here at larger scale and with all of the furnishings drawn in, giving a clearer idea of the livability of the units.

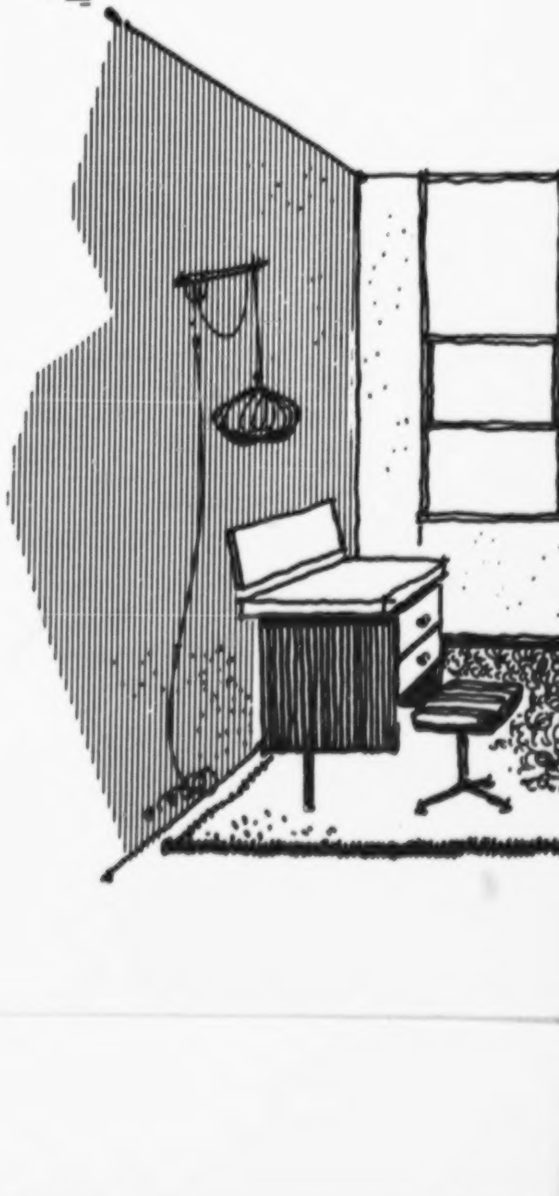
On the next page are two perspective views of apartment interiors from this plan.


BR
L-D
BA
K
BR
BA
BR
BA
BR
BA
K
BR
BR
L-D
0
5
10
SCALE
FT

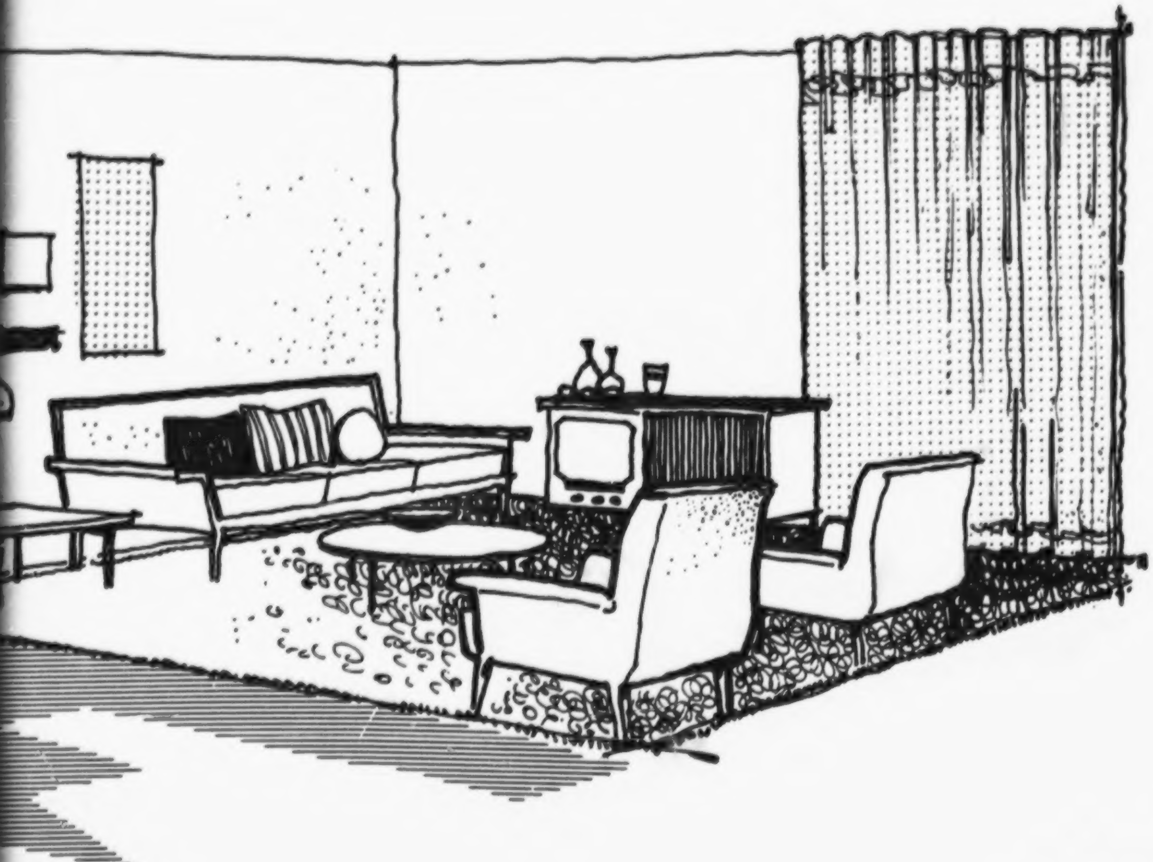
FLOOR PLAN E SHOWING FURNITURE LAYOUT

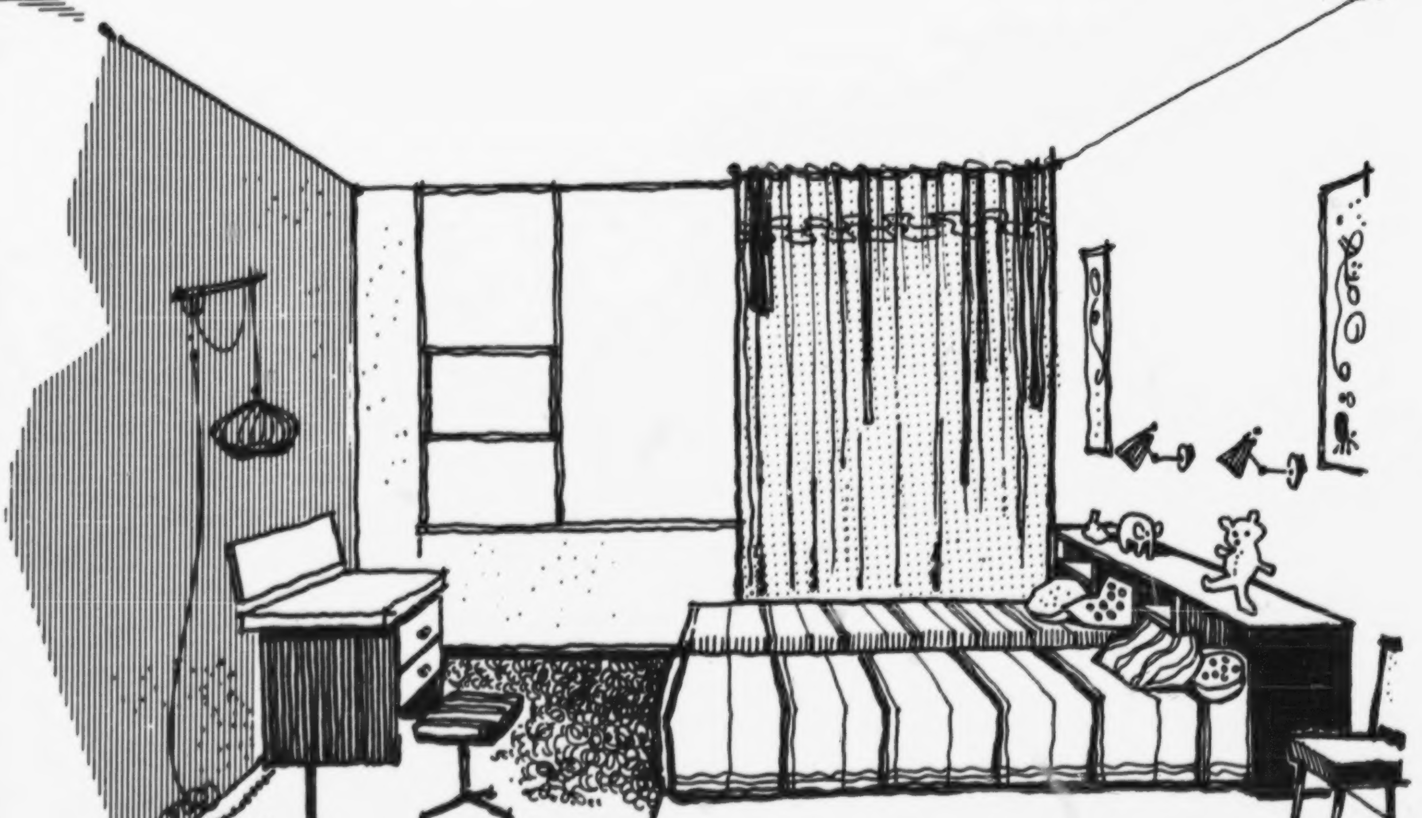


PERSPECTIVE OF LIVING-DINING ROOM (SEE PLAN)



PERSPECTIVE OF BEDROOM (SEE PLAN)





TOWER SCHEME

2 OPEN-CORRIDOR SCHEME

In this type of building all of the apartments are reached by means of outdoor corridors or "elevated sidewalks," as they are sometimes called. The characteristic shape of such a building is long and thin. The open-corridor scheme has been used for low and middle-income housing in many places, both in this country and abroad.

Improved livability is the outstanding advantage of this scheme. Every apartment has through-ventilation and two exposures, and every apartment can have the most favorable orientation. All rooms, including bathrooms, have outside light and ventilation. The interior corridor, which in practice is often an unpleasant space — narrow, dark, and smelly — is eliminated entirely. These gains are partially offset by some loss of privacy for the rooms that open on the corridor.

The open-corridor scheme eliminates the cost of mechanical ventilation for the bathrooms and the cost of the interior corridor with its expensive finishes. But the open-corridor, being "single-loaded," must be at least 1½ times as long as the interior corridor. Since codes limit the maximum distance from an apartment to a stair, the open-corridor building must either be content with few apartments per floor or, as in the example shown here, it must separate the two required stairs. The open-corridor, of course, need not be heated but some provision must be made for snow removal; in New York the Building Department requires the installation of electric heating cable in the floors of all open corridors. Since all apartment doors open to the outside, these doors must be of the exterior type and must be weatherstripped. The long, thin building shape, with its high proportion of perimeter to enclosed area, is not basically economical, nor, in a high-rise building, is it basically stable; extra cost for wind-bracing must be assumed.

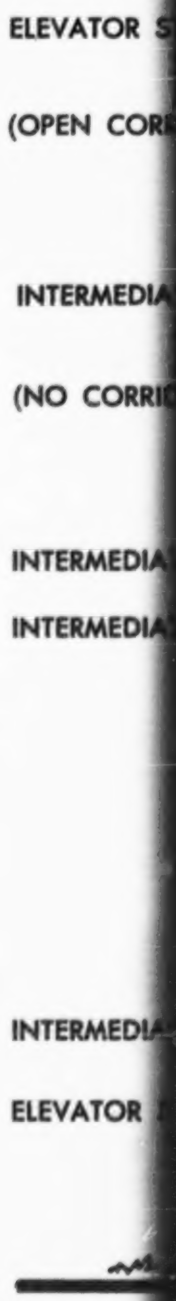
In view of all the items noted in the previous paragraph, it might be concluded that the economic position of the open-corridor scheme is unfavorable. But this is not the case. Recent cost studies for a newly designed public housing project in New York indicate very substantial cost savings resulting from the use of the open-corridor scheme.

In the example presented here and on the following pages, the open-corridor scheme has been combined with skip-stop elevators. In this arrangement the elevators stop only at every third floor; tenants on the intermediate floors have to walk up or down one floor. The open corridor occurs only at elevator-stop floors. All apartments open off the corridor; stairs are within the apartments and are maintained by the tenant. This scheme has been used in a noted upper-income project in Cambridge, Massachusetts, and in a proposed low-income project in New York.

The skip-stop scheme saves the cost of two out of three corridors and elevator doors and controls. Against this saving must be balanced the cost of the private stairs and the fire escape balconies in two out of three of the apartments. A significant advantage of this scheme is the elimination of most of the privacy problem. By placing the larger apartments on the intermediate floors, it was possible to arrange the plan so that no bedroom opens on a corridor.

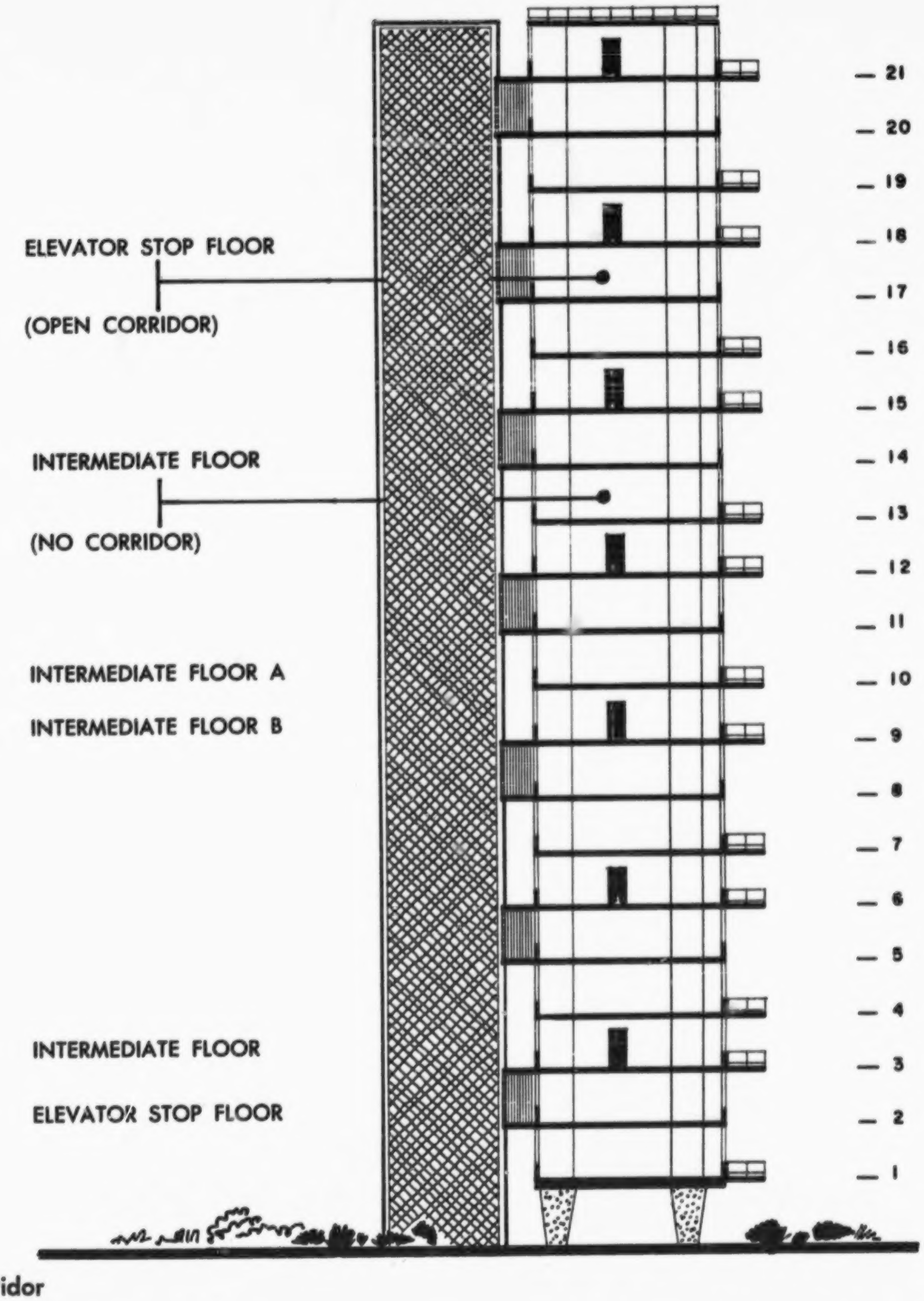
The structural system employs regularly spaced reinforced concrete columns, two per bay, with the floor slabs cantilevered 4 feet beyond the columns on each side. This framing system is discussed in detail in Chapter Two. Stair and elevator towers have been placed outside the building proper, and designed to supply windbracing for the tall, narrow building.

Required distribution of apartment types is provided in one building. The two basic floor plans are detailed on the following pages along with alternate floor plans required for complete distribution. This distribution is explained in chart form on the following page.



Cross-section through Open-Corridor

SEE PLAN NEXT PAGE


ELEVATOR STOP FLOOR
(OPEN CORRIDOR)
INTERMEDIATE FLOOR
(NO CORRIDOR)
INTERMEDIATE FLOOR A
INTERMEDIATE FLOOR B
INTERMEDIATE FLOOR
ELEVATOR STOP FLOOR
21
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1

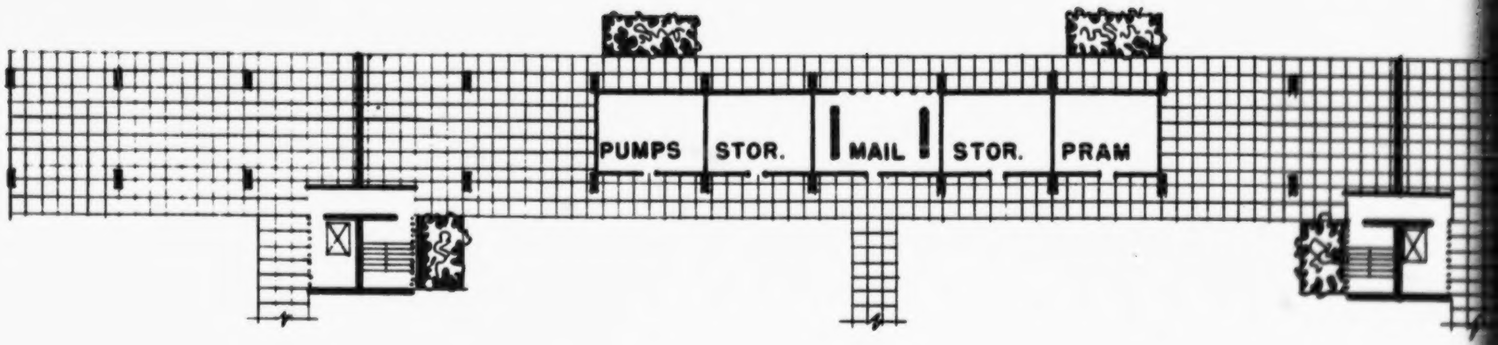
-section through Open-Corridor

PLAN NEXT PAGE

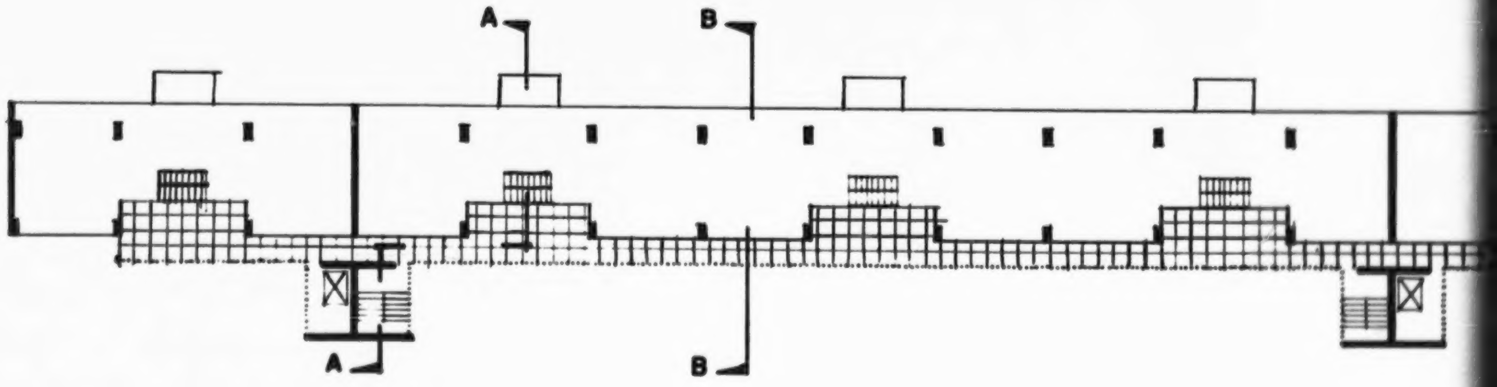
SECTION B-B

0 5 10 15 20 25
SCALE FT.

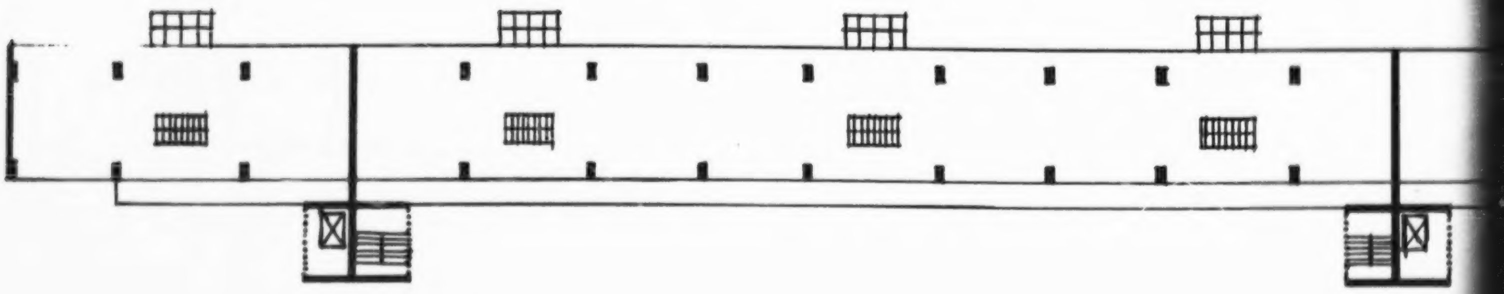
OPEN-CORRIDOR SCHEME


PUMPS
STOR.
MAIL
STOR.
PRAM

LOBBY FLOOR PLAN



ELEVATOR STOP FLOOR PLAN



INTERMEDIATE FLOOR PLAN

OPEN-CORRIDOR SCHEME

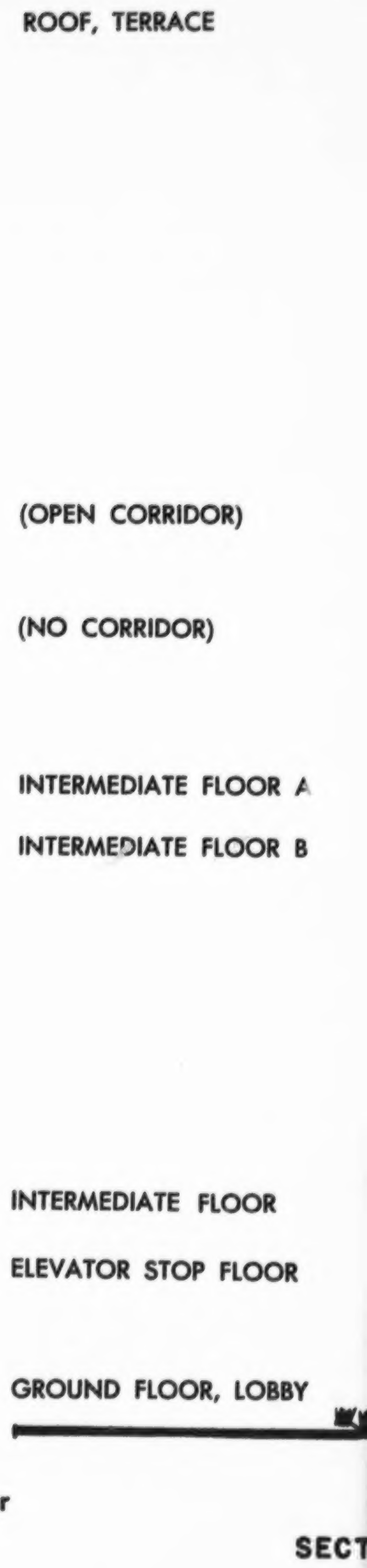
The required distribution of apartment types is provided in one building by means of two typical floor plans along with their alternate layouts. The distribution is as follows:

Floor plan	Number of uses	Apartment types (by construction rooms)						Total
		2	3	4	5	6	7	
Elevator-stop (2,5,8,11,14,17,20)	7	—	21	56	—	—	—	77
Intermediate A. (3,6,9,12,15,18,21)	7	—	7	—	56	7	—	70
Intermediate B. (1,4,7,10,13,16,19)	7	7	—	—	56	—	7	70
Total	21	7	28	56	112	7	7	217
Distribution by %		**3.2**	**12.9**	**25.8**	**51.7**	**3.2**	**3.25**	**100**
Required distribution		**3.5**	**16.5**	**25.0**	**45.0**	**8.5**	**1.5**	**100**

There are 973 construction rooms or 1081½ rental rooms, for an estimated average occupancy of 896 people. For the twenty-one floors the average gross area per construction room is 208 square feet.

The three schematic plans on the opposite page, along with the section on this page, explain how the building works. As in the other examples in this Chapter, there is no basement and the facilities usually found in the basement are located on the ground floor. These include perambulator storage, tenant storage, laundry, pumps, meters, etc. The remainder of the first floor is left open for use as covered play space or sitting areas.

The two typical floor plans with their alternate layouts are shown at larger scale in the following pages. Note that all apartments are entered from the elevator-stop floors (2,5,8,11,14,17,20) which are shown shaded on the section. Tenants on the intermediate floors A and B reach their apartments by means of private stairs. Fire-escape balconies connecting adjacent apartments on the intermediate floors, are required by the building department.



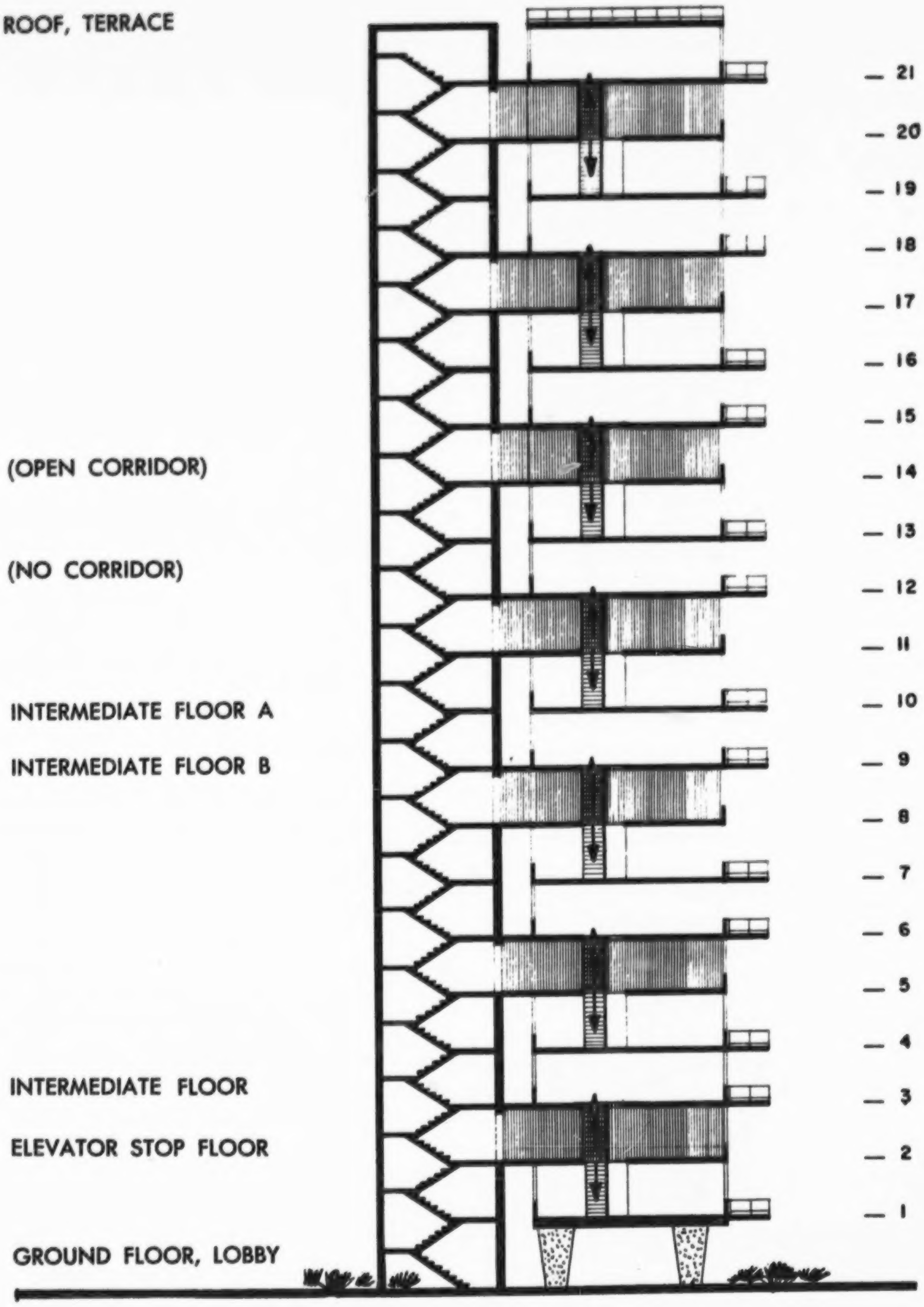
Cross-section through Elevator Tower

SEE PLAN THIS PAGE

	Total
–	77
–	70
7	70
7	217
3.25	**100**
1.5	**100**

ection through Elevator Tower

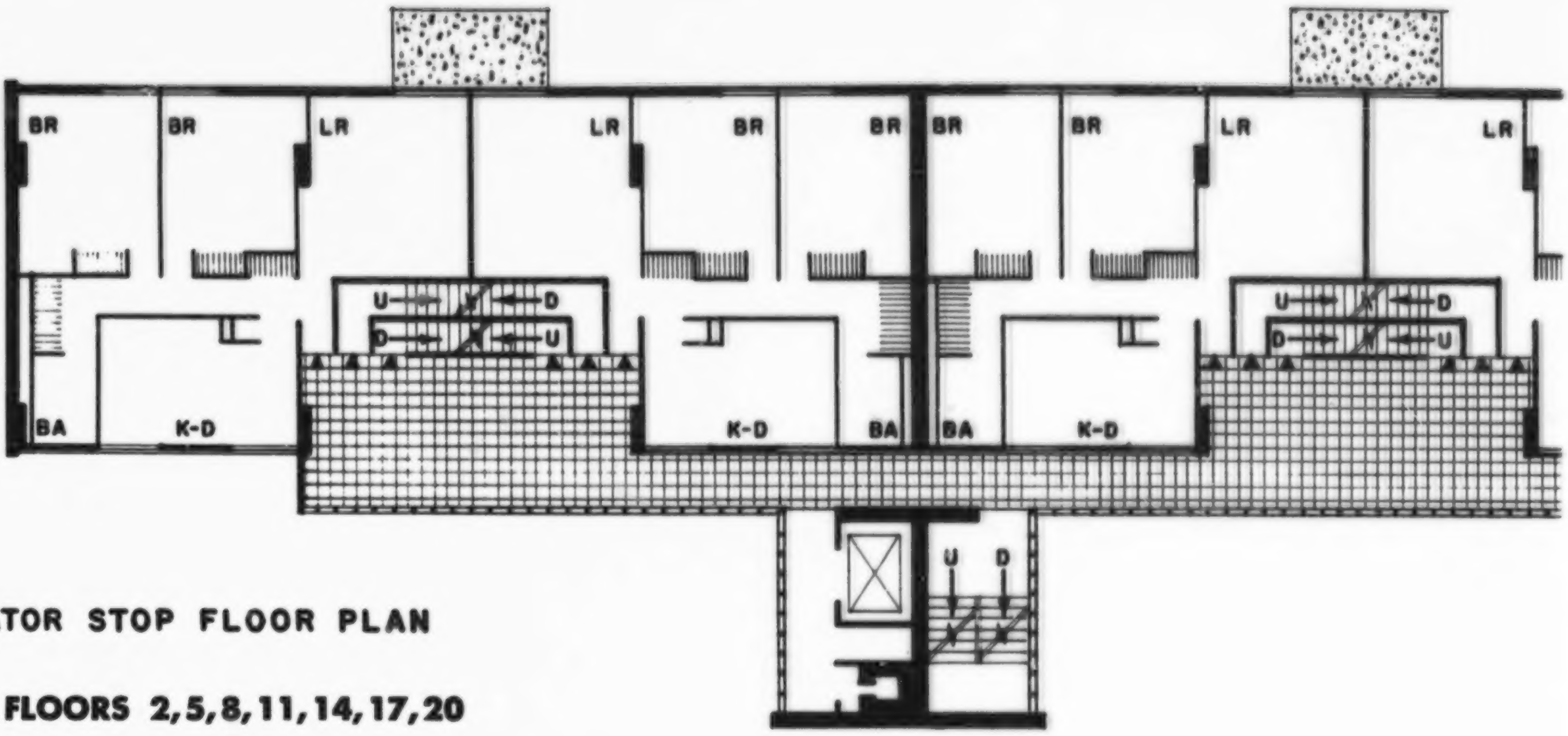
LAN THIS PAGE


ROOF, TERRACE
(OPEN CORRIDOR)
(NO CORRIDOR)
INTERMEDIATE FLOOR A
INTERMEDIATE FLOOR B
INTERMEDIATE FLOOR
ELEVATOR STOP FLOOR
GROUND FLOOR, LOBBY
21
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1

SECTION A–A

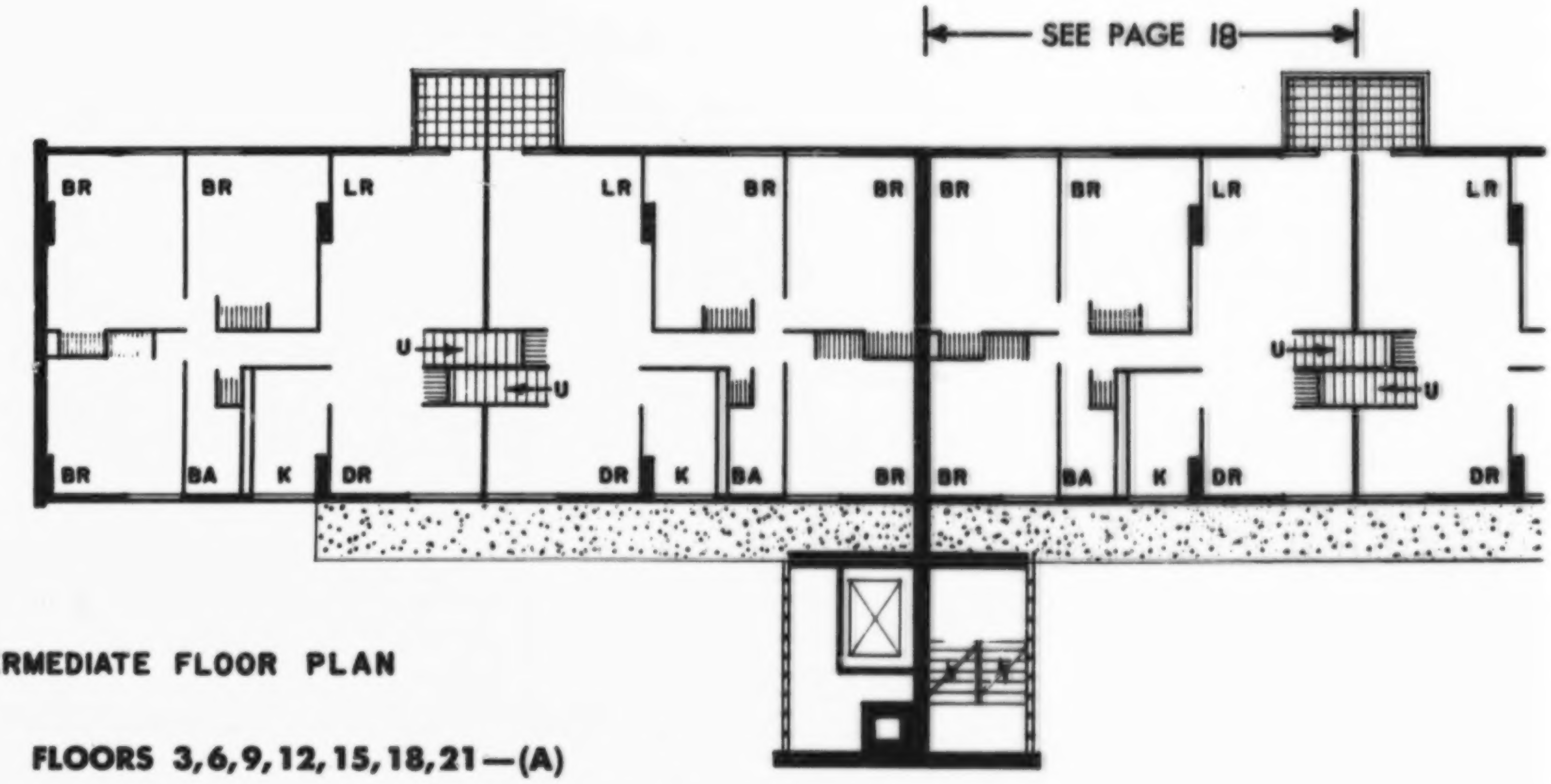
0 5 10 15 20 25
SCALE FT

OPEN-CORRIDOR SCHEME


BR
BR
LR
LR
BR
BR
BR
BR
LR
LR
U
D
D
U
BA
K-D
K-D
BA
BA
K-D
U
D

ELEVATOR STOP FLOOR PLAN

FLOORS 2,5,8,11,14,17,20


SEE PAGE 18
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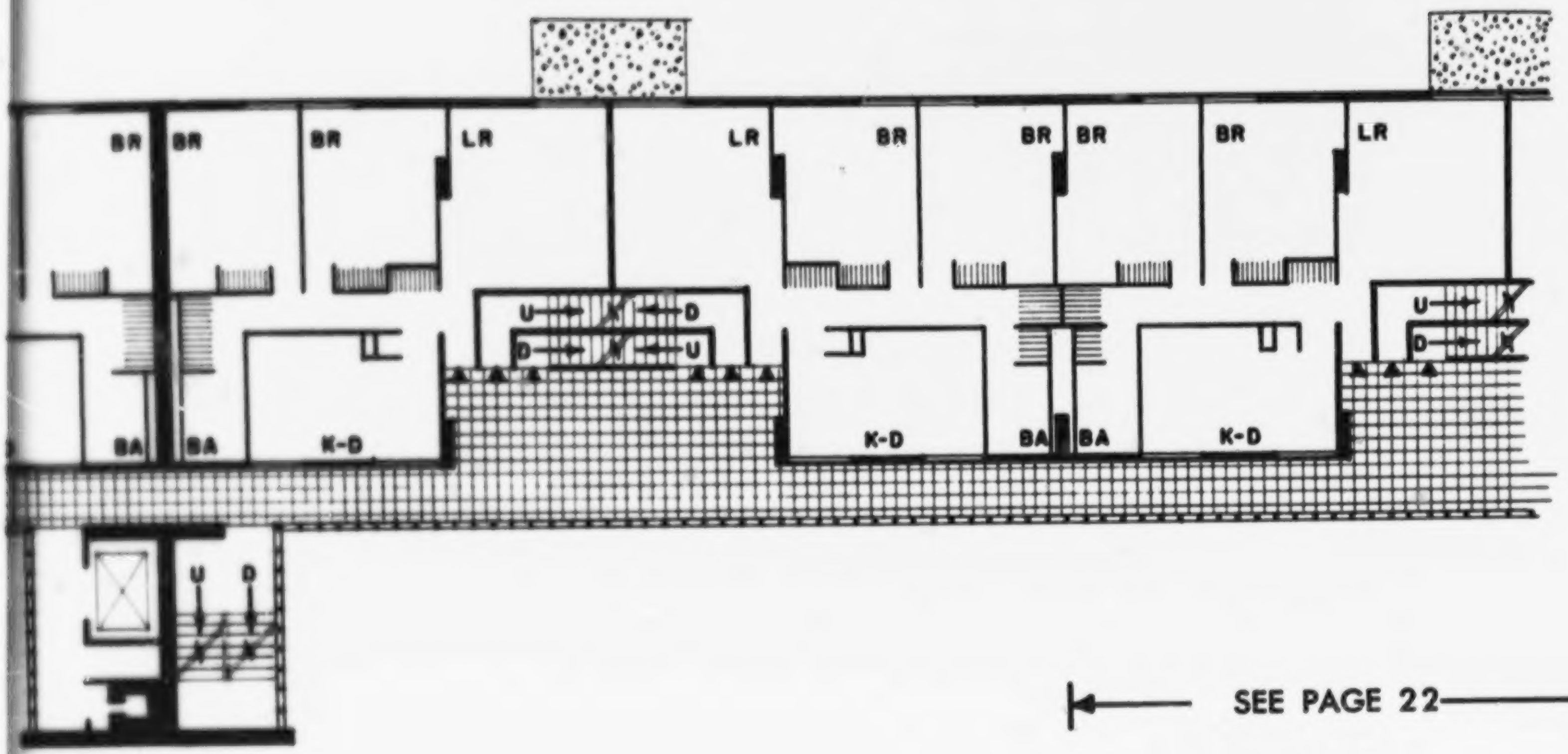
BR
BR
BR
LR
LR
U
U
U
U
BR
BA
K
DR
DR
K
BA
BR
BR
BA
K
DR
DR

INTERMEDIATE FLOOR PLAN

FLOORS 3,6,9,12,15,18,21—(A)

FLOORS 1,4,7,10,13,16,19—(B)

OPEN-CORRIDOR SCHEME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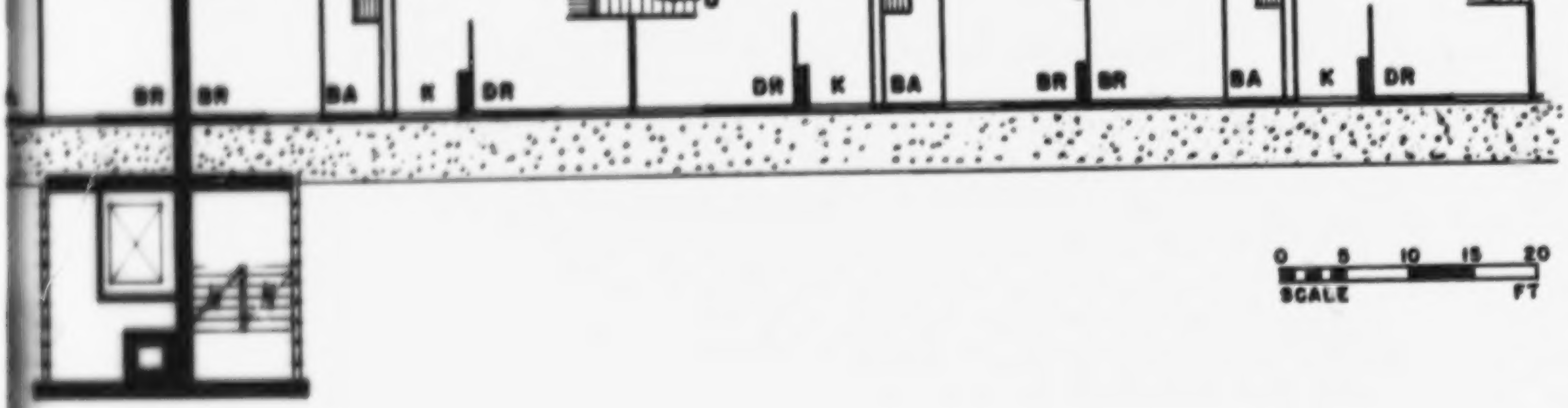
LR
LR
BR
BR
BR
BR
LR
U
D
D
U
U
D
U
D
BA
BA
K-D
K-D
BA
BA
K-D
U
D

SEE PAGE 22

SEE PAGE 18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BR
LR
LR
BR
BR
BR
BR
LR
U
U
U
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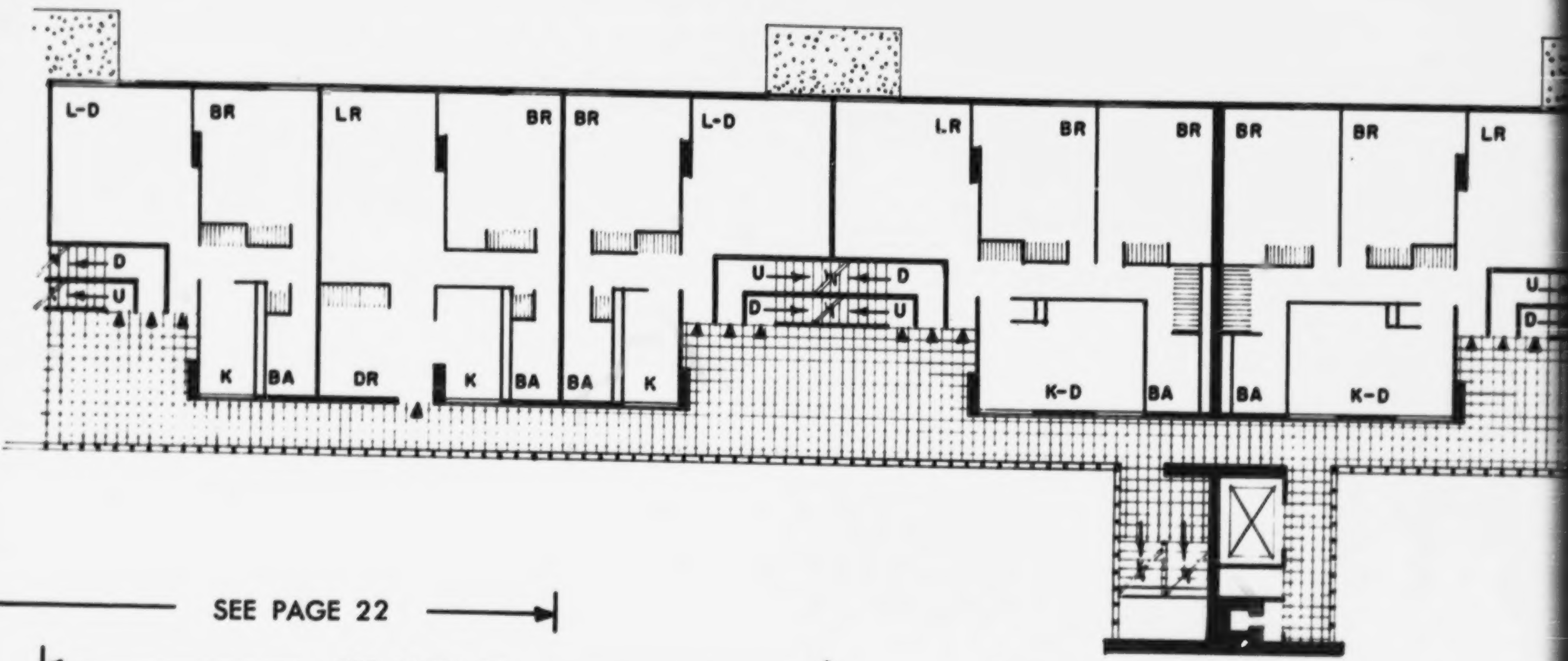
BR
BA
K
DR
DR
K
BA
BR
BR
BA
K
DR
0
5
10
15
20
SCALE
FT


L-D
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LR
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L-D
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BR
BR
LR
D
U
U
D
D
U
U
D
K
BA
DR
K
BA
BA
K
K-D
BA
BA
K-D

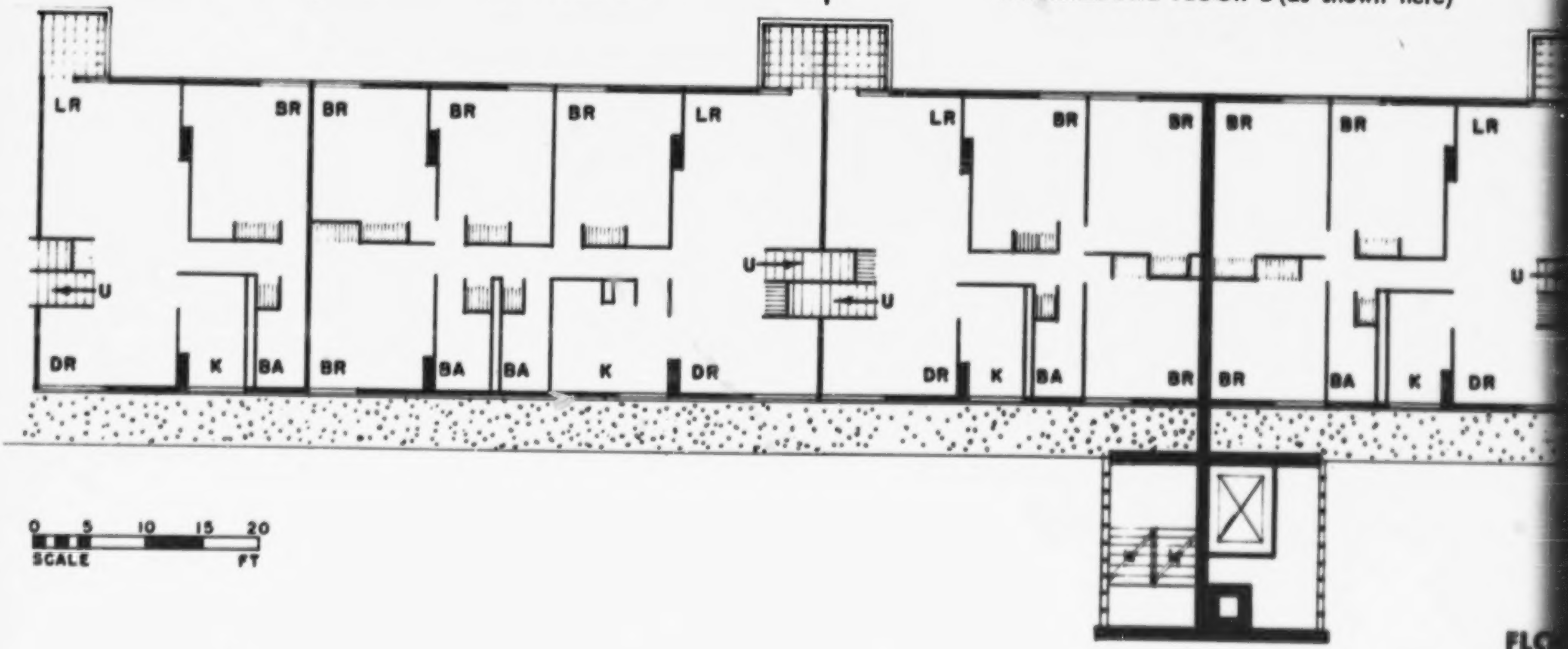
SEE PAGE 22

SEE PAGE 23

SEE PAGE 20

INTERMEDIATE FLOOR A (alternate on page 23)

INTERMEDIATE FLOOR B (as shown here)


LR
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BR
LR
LR
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BR
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BR
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U
U
U
U
DR
K
BA
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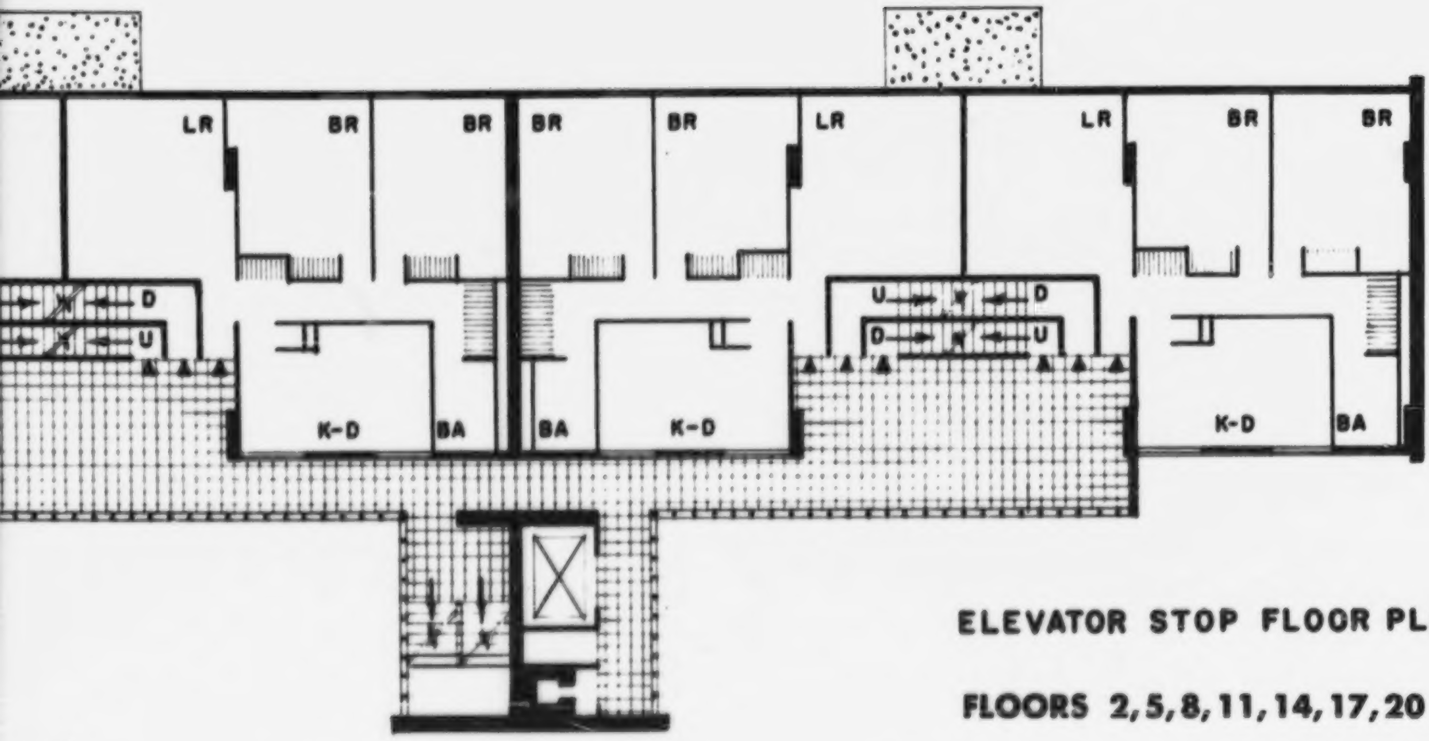
15
20
SCALE
FT

FLO

FLO

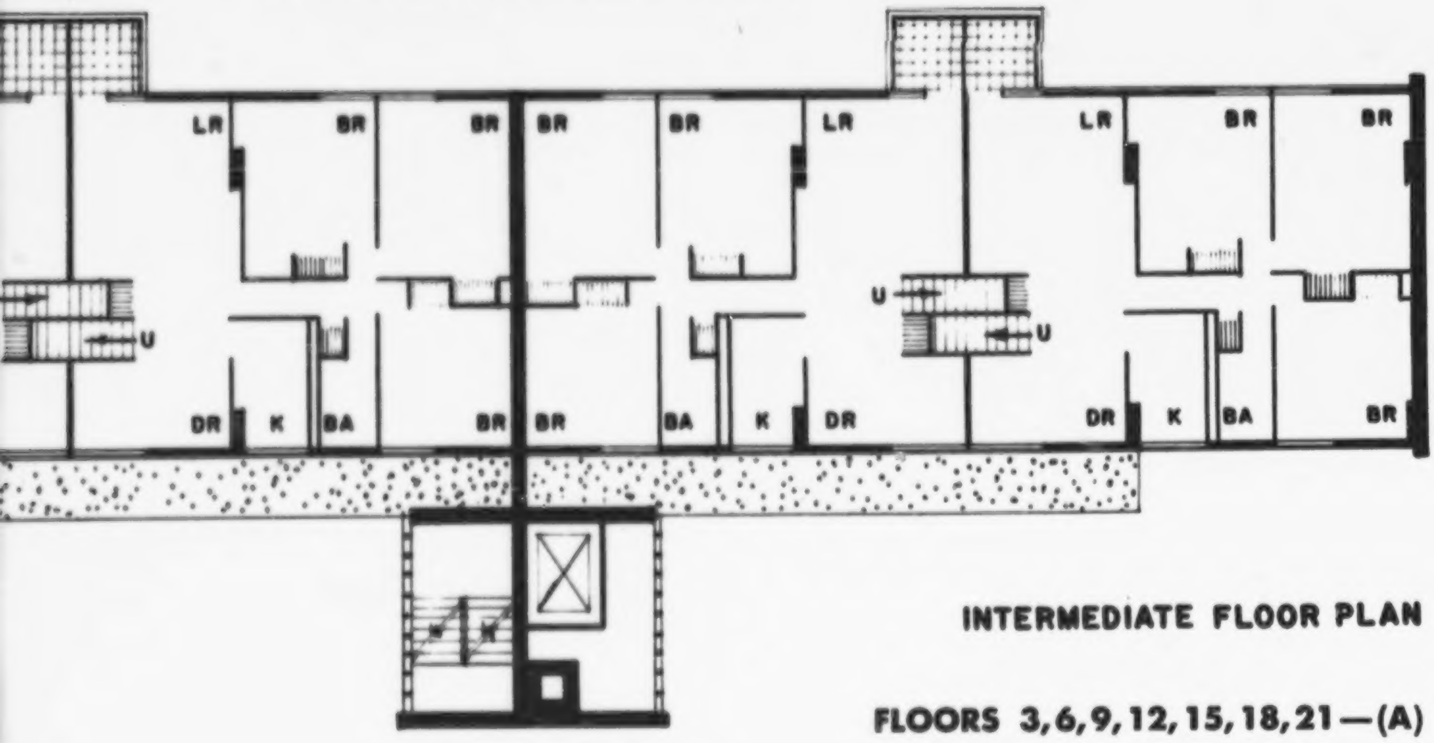

LR
BR
BR
BR
BR
LR
LR
BR
BR
D
U
U
D
D
U
K-D
BA
BA
K-D
K-D
BA

ELEVATOR STOP FLOOR PLAN

FLOORS 2,5,8,11,14,17,20

INTERMEDIATE FLOOR A (alternate on page 23)

INTERMEDIATE FLOOR B (as shown here)


LR
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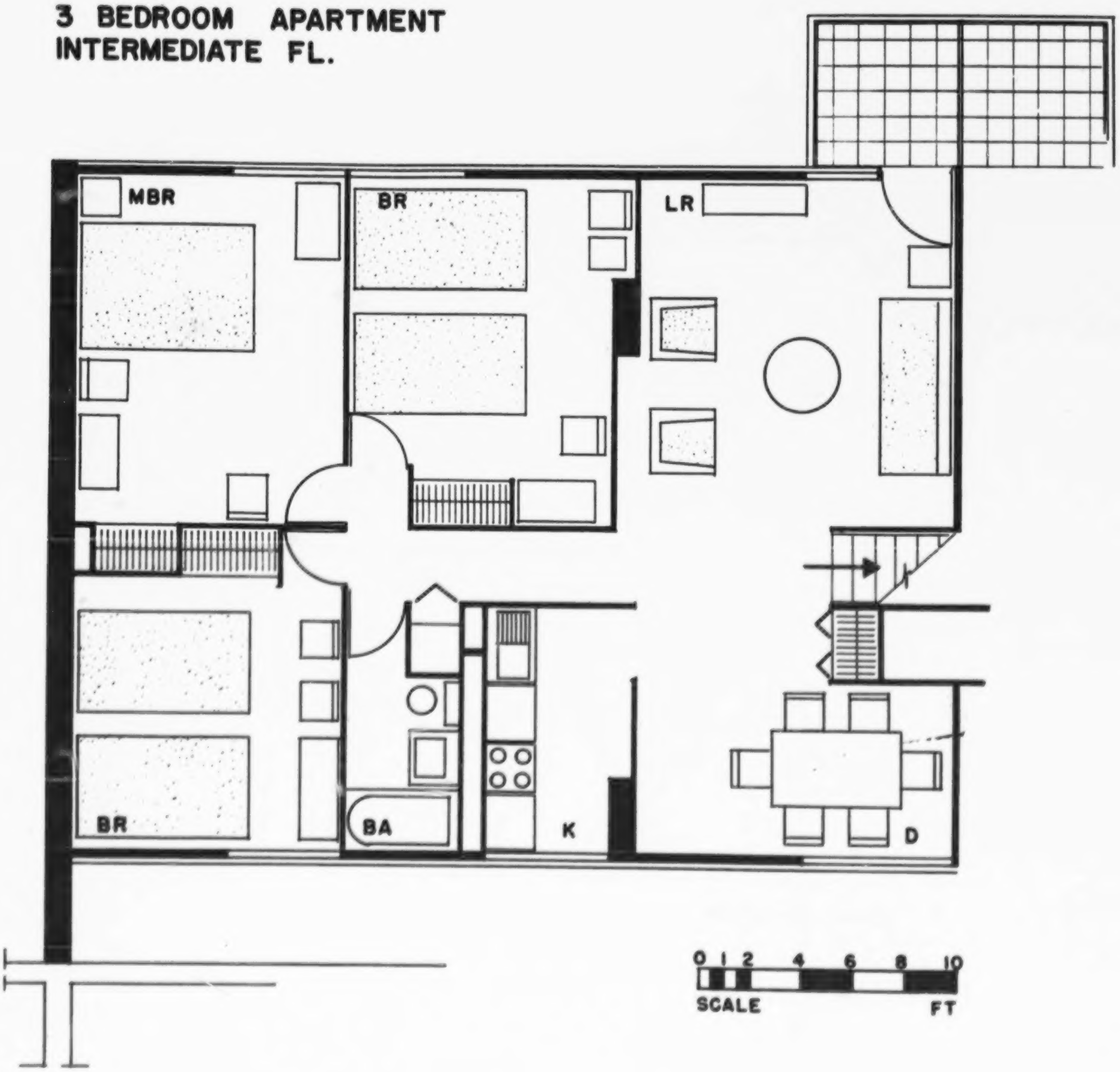
LR
LR
BR
BR
U
U
U
DR
K
BA
BR
BR
BA
K
DR
DR
K
BA
BR

INTERMEDIATE FLOOR PLAN

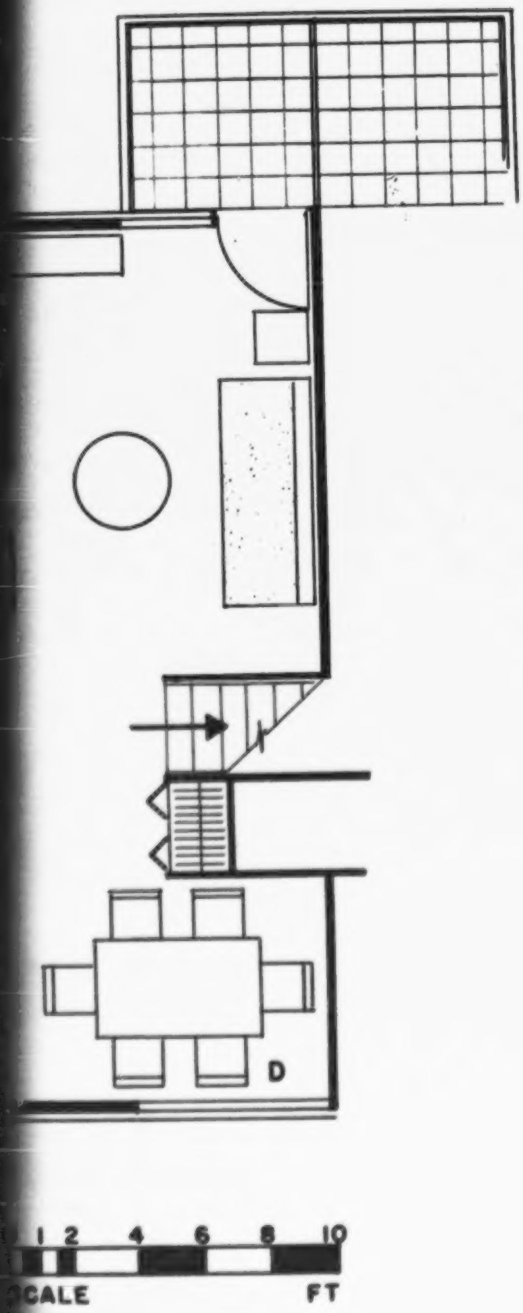
FLOORS 3,6,9,12,15,18,21—(A)

FLOORS 1,4,7,10,13,16,19—(B)

3 BEDROOM APARTMENT
INTERMEDIATE FL.

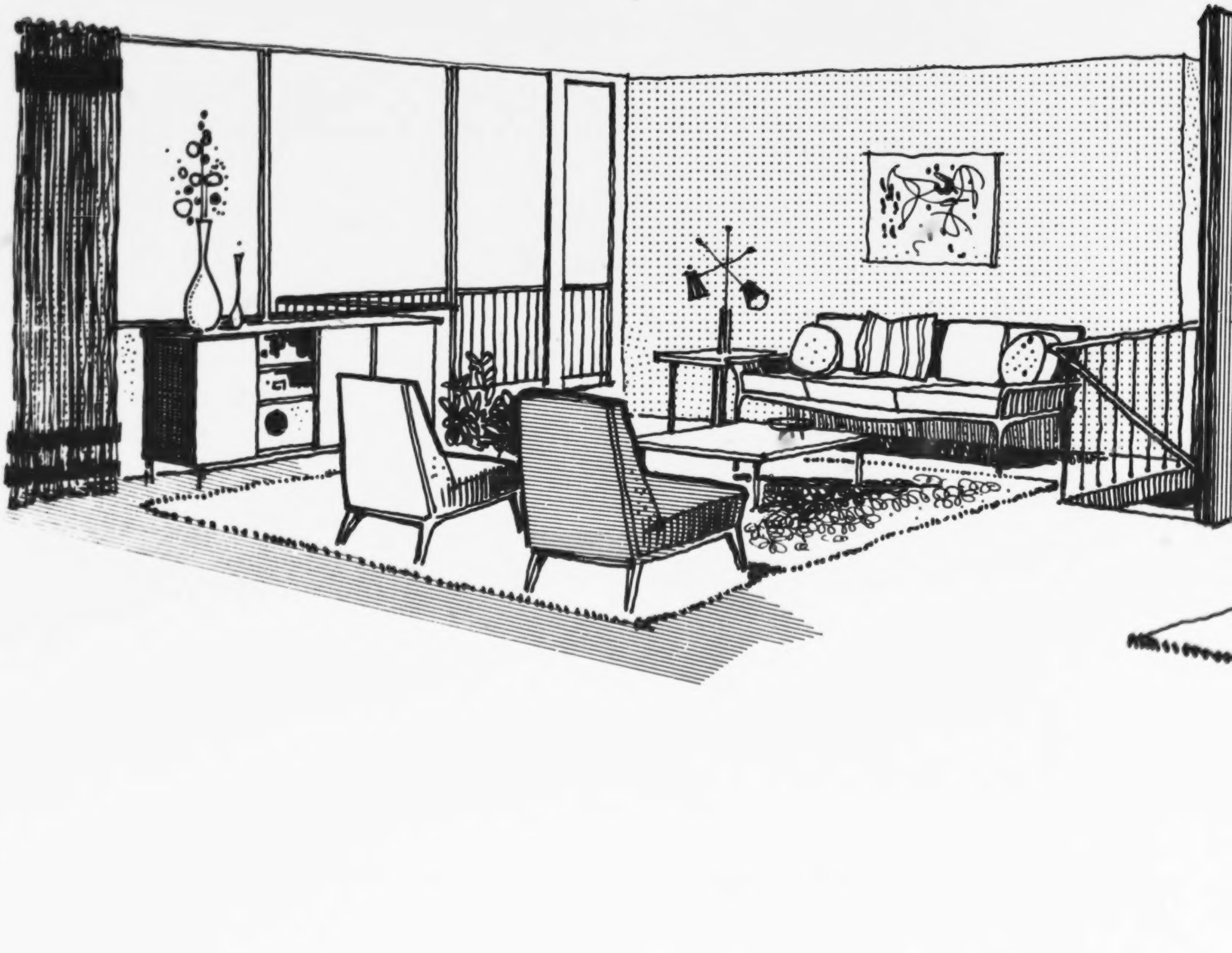

MBR
BR
LR
BR
BA
K
D
0 1 2 4 6 8 10
SCALE
FT

OPEN-CORRIDOR SCHEME

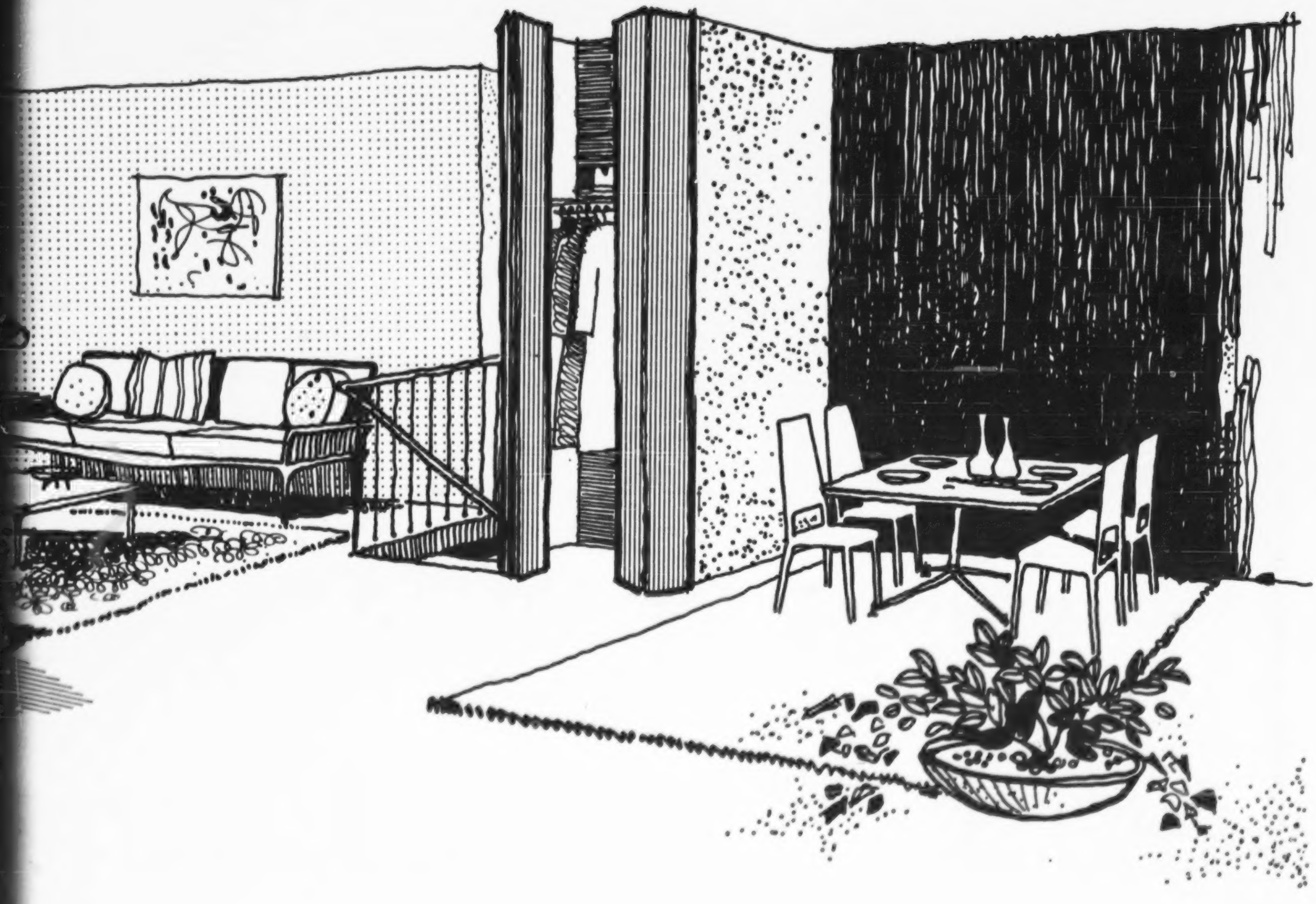


This apartment of five construction rooms is the predominant unit in the building. It always occurs on an intermediate floor, and is reached by means of a stair up or down from the corridor floor. The required fire-escape balcony has been enlarged enough to be usable also for outdoor living. The apartment has through-ventilation and two exposures; all rooms have outside light and ventilation.

A perspective view of the interior of this apartment is shown on the opposite page.

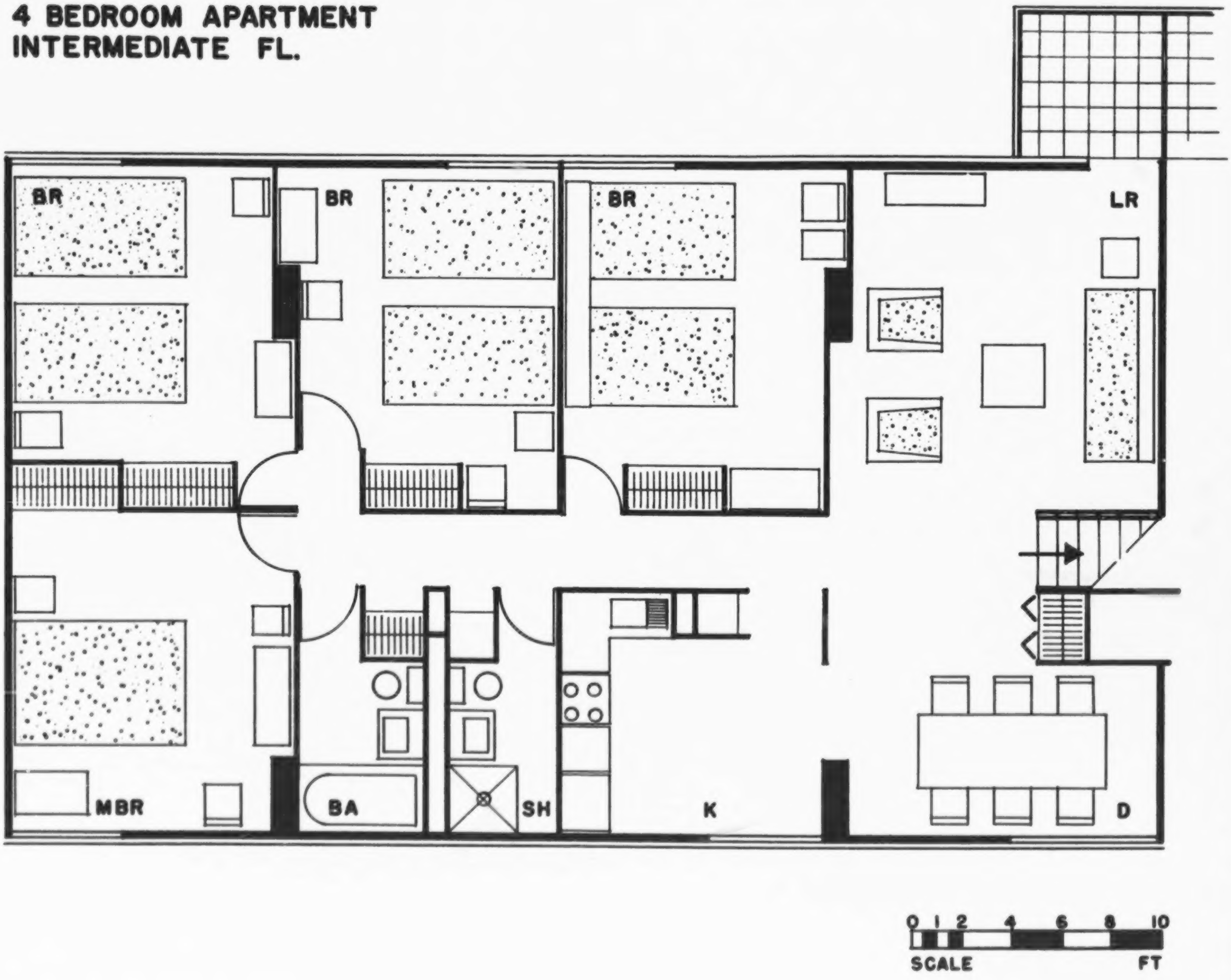


PERSPECTIVE OF LIVING-DINING ROOM (SEE PLAN)



OPEN-CORRIDOR SCHEME

4 BEDROOM APARTMENT
INTERMEDIATE FL.

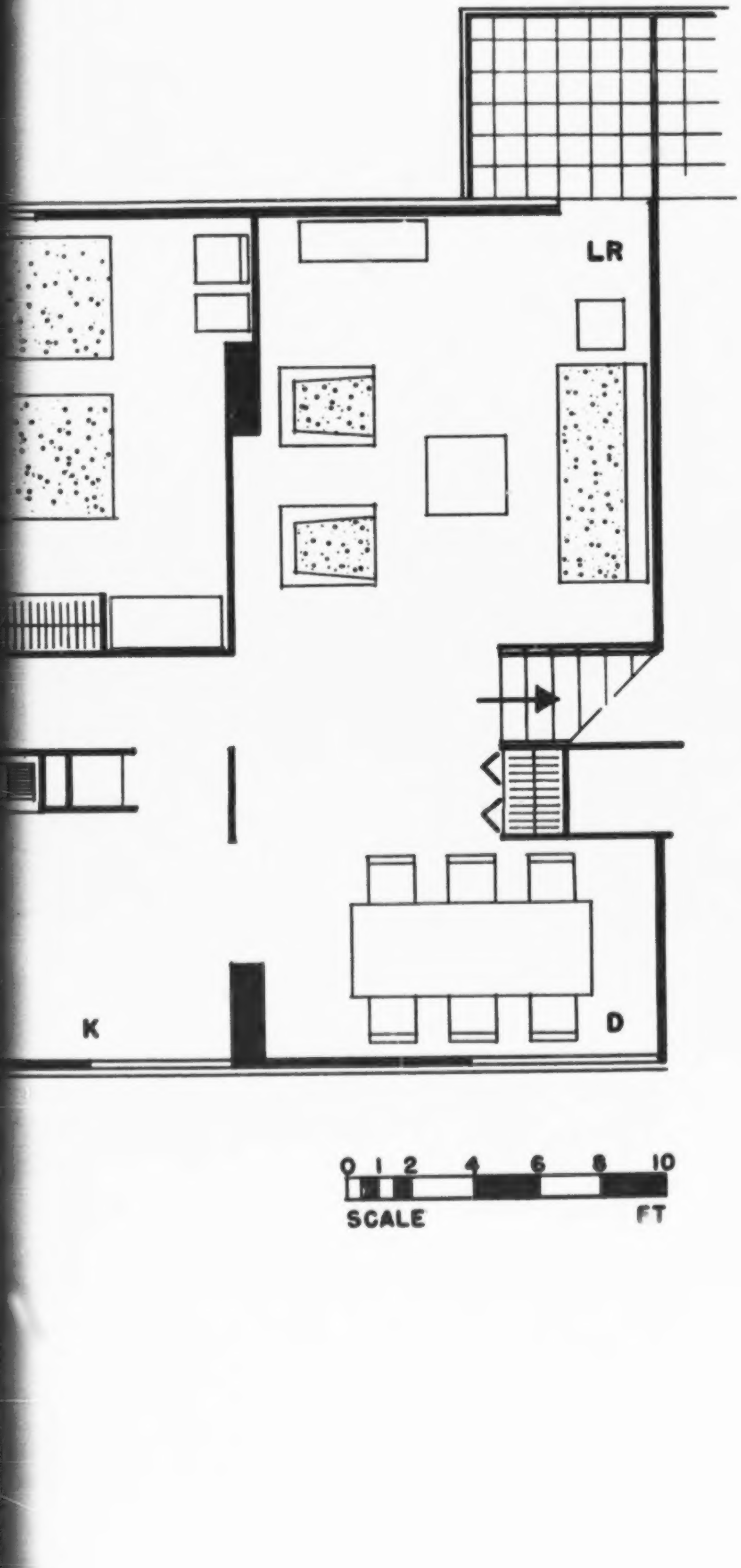

BR
BR
BR
LR
MBR
BA
SH
K
D
0 1 2 4 6 8 10
SCALE
FT

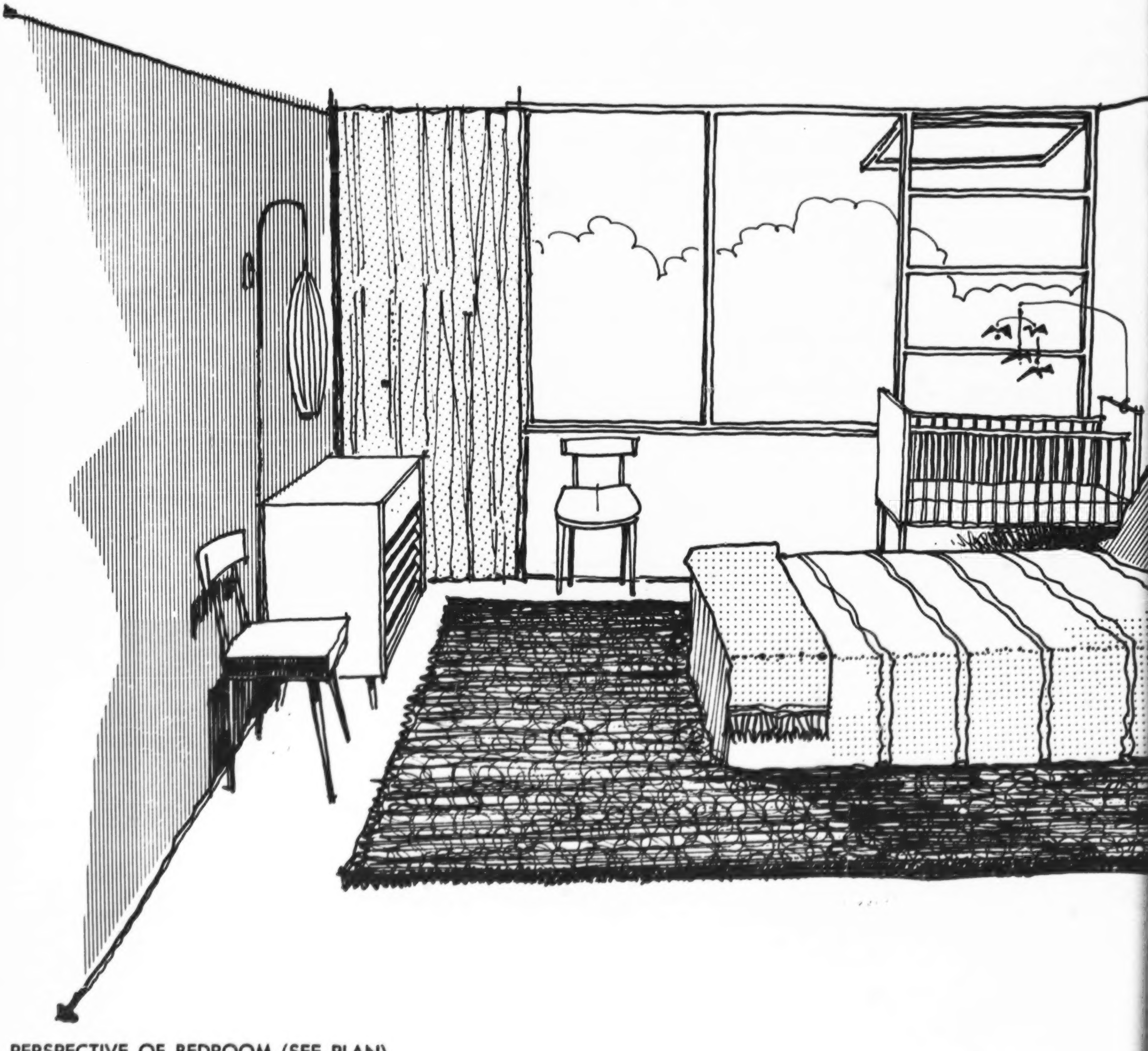
OPEN-CORRIDOR SCHEME

This apartment of six construction rooms occurs only on intermediate floors. Like the five-room units, it is reached by means of a private stair, has a balcony, through-ventilation, and two exposures.

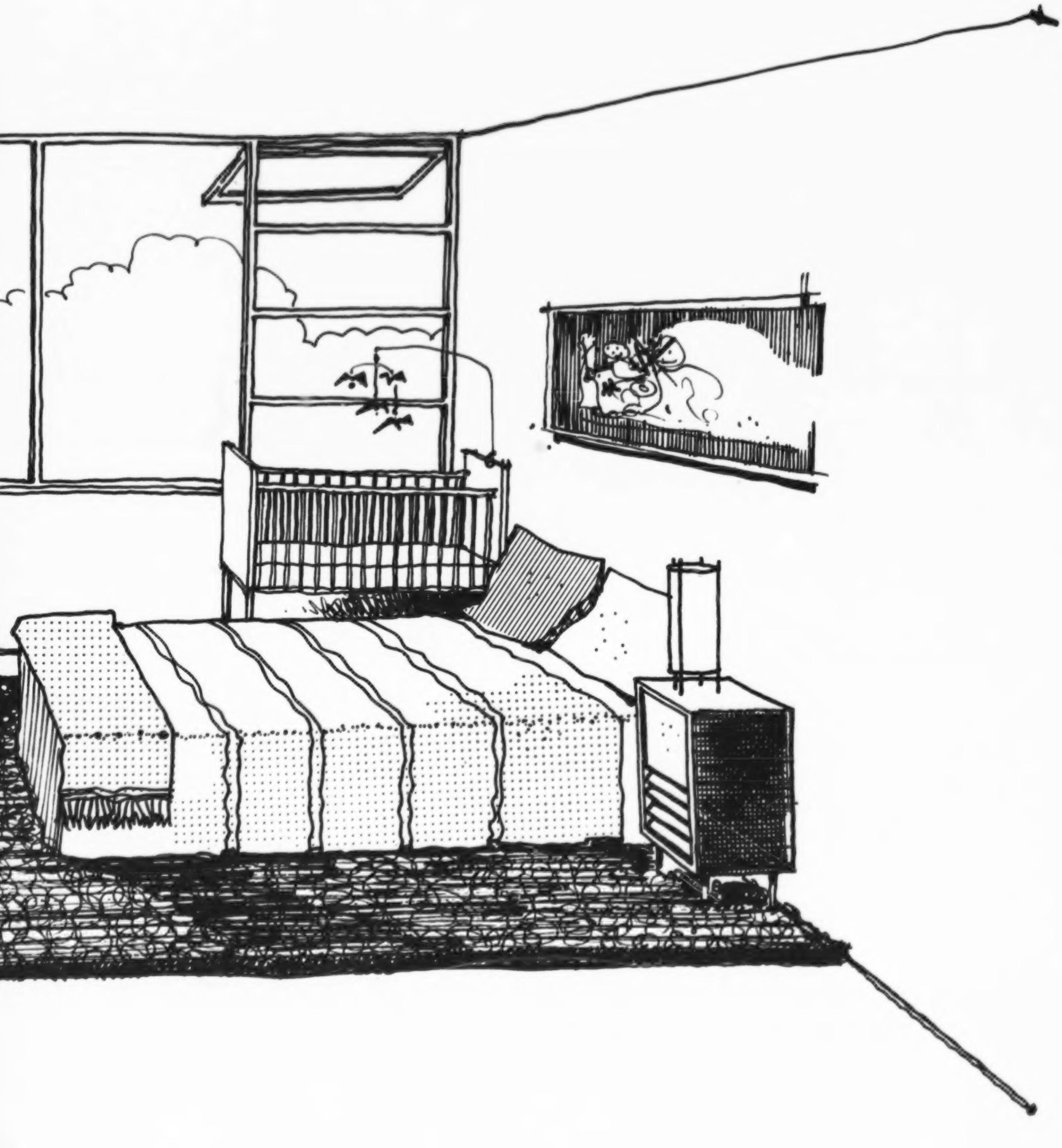
A perspective view of the master bedroom of this apartment is shown on the opposite page.

Plans of the one and two-bedroom apartments are shown on the page following. These smaller units usually occur on the corridor floors. Note that although all apartments have through-ventilation, no living rooms or bedrooms are on the corridor side.

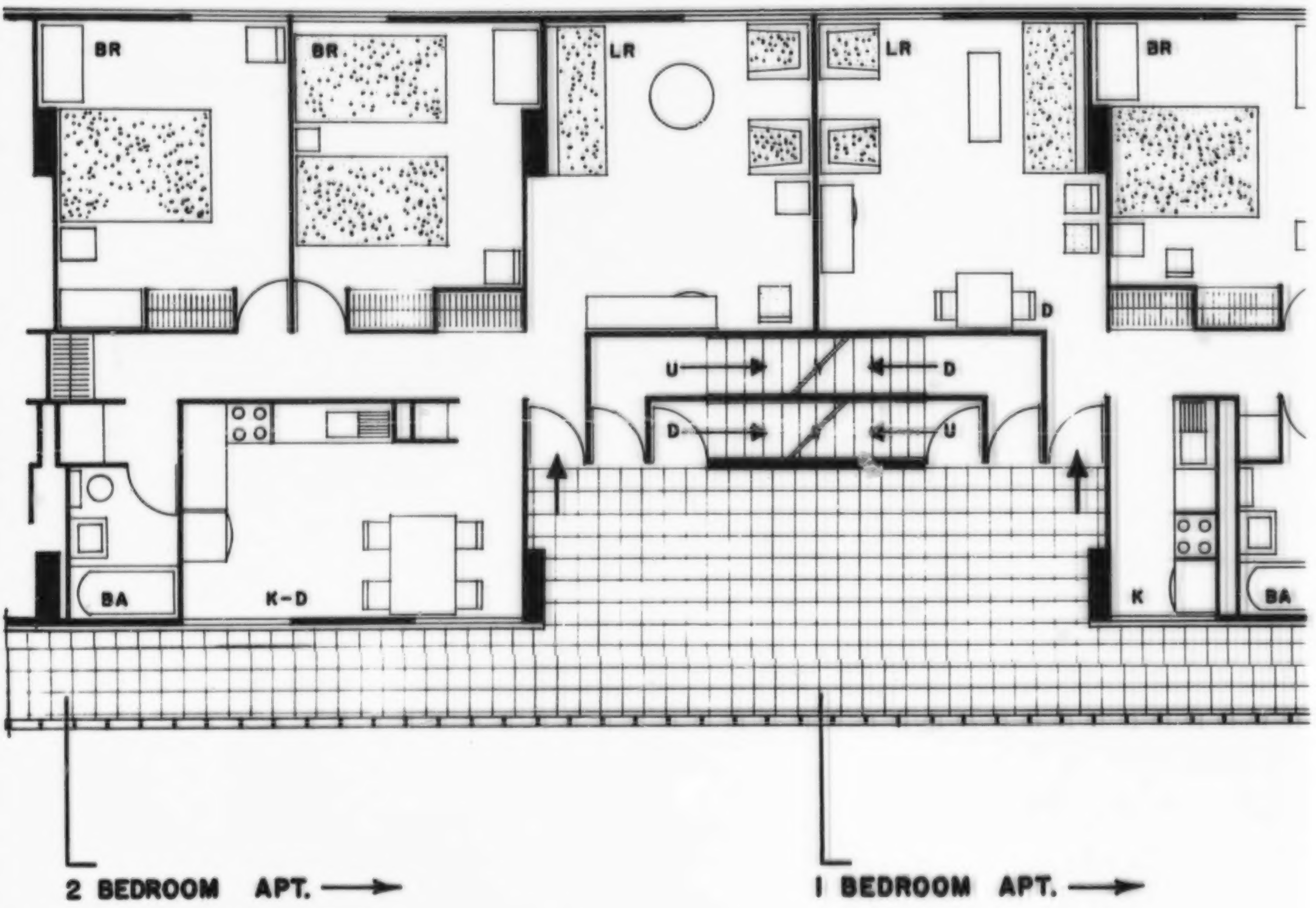




PERSPECTIVE OF BEDROOM (SEE PLAN)

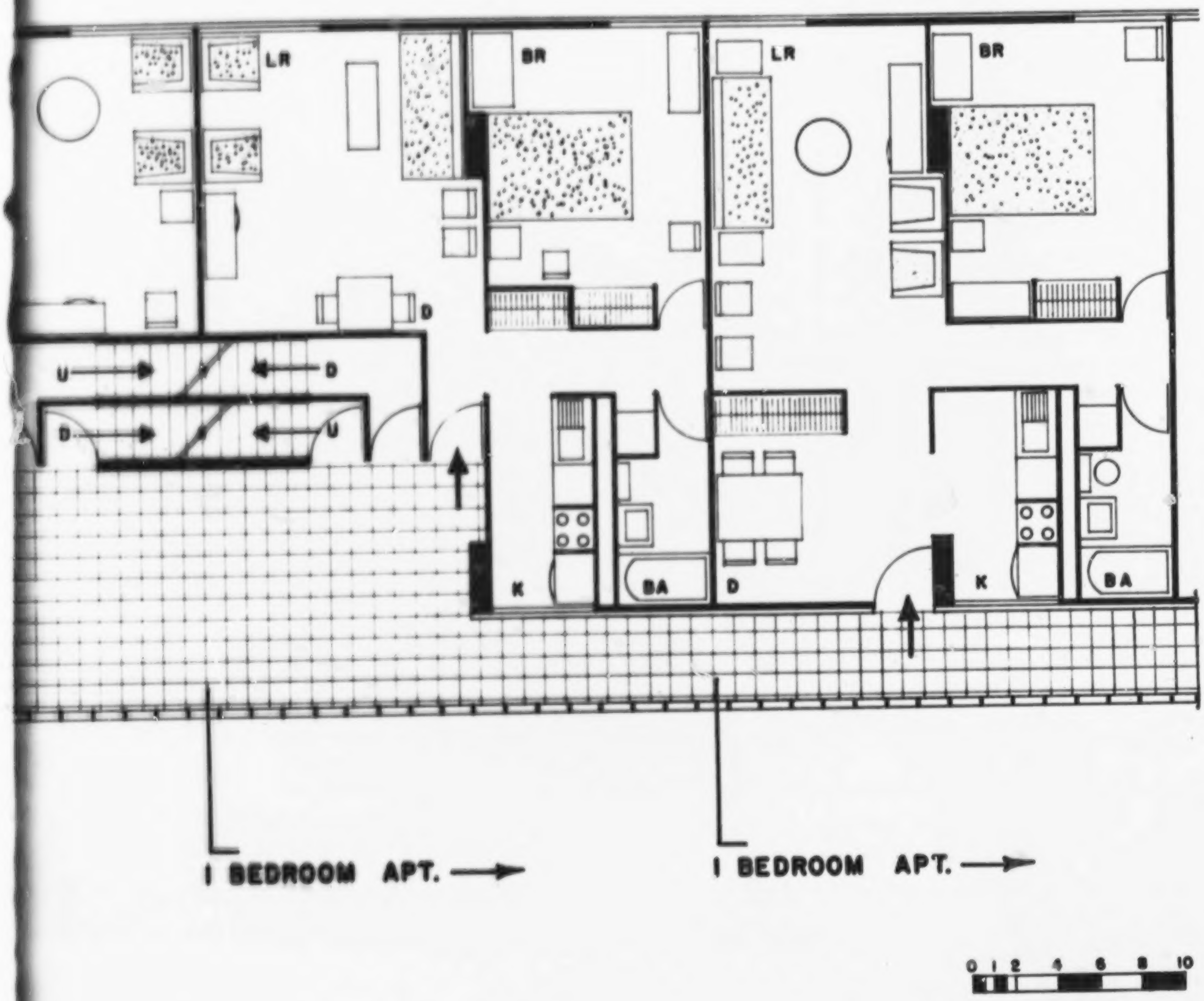


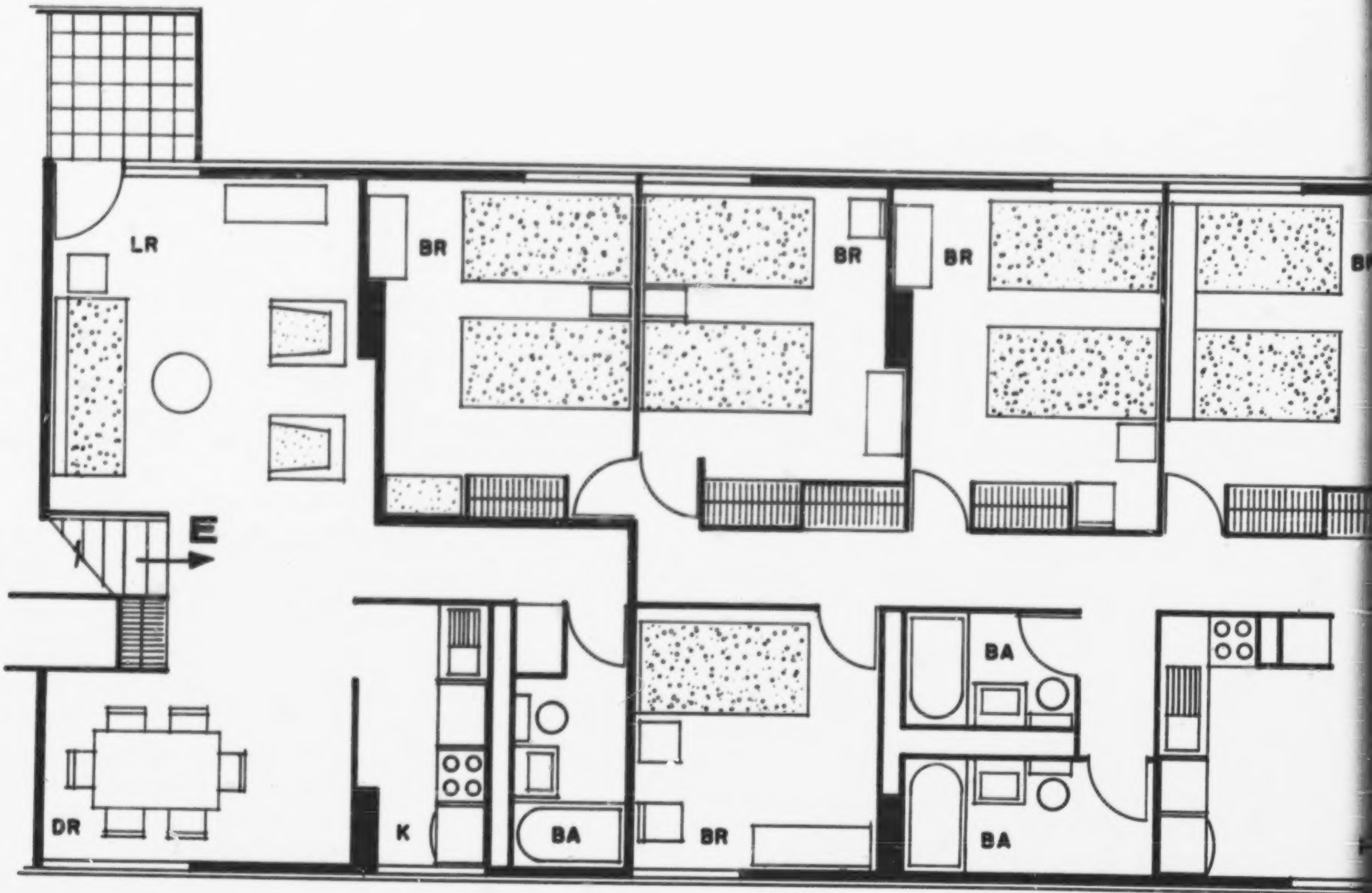
OPEN-CORRIDOR SCHEME


BR
BR
LR
LR
BR
D
U
D
D
U
BA
K-D
K
BA
2 BEDROOM APT. →
1 BEDROOM APT. →

ELEVATOR STOP FLOOR PLAN

OPEN-CORRIDOR SCHEME

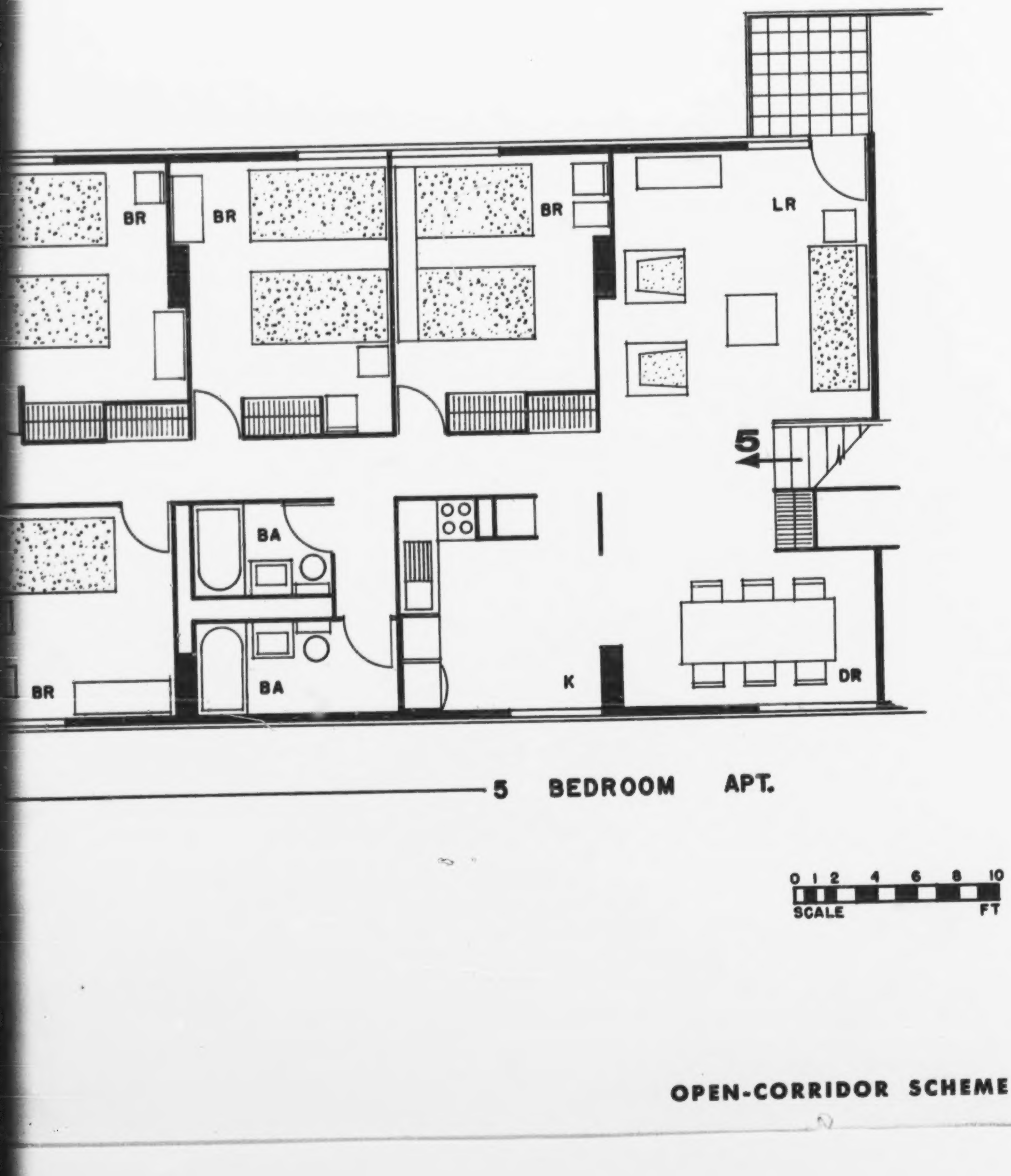

LR
BR
LR
BR
D
U
D
D
U
K
BA
D
K
BA
1 BEDROOM APT.
1 BEDROOM APT.
0 1 2 4 6 8 10


LR
BR
BR
BR
E
DR
K
BA
BR
BA
BA

EFFICIENCY APT. ——— | ——— 5 B

INTERMEDIATE FL. PLAN

FLOORS 3,6,9,12,15,18,21—(A)


BR
BR
BR
LR
5
BA
BA
BR
K
DR
5 BEDROOM APT.
0 1 2 4 6 8 10
SCALE
FT

OPEN-CORRIDOR SCHEME

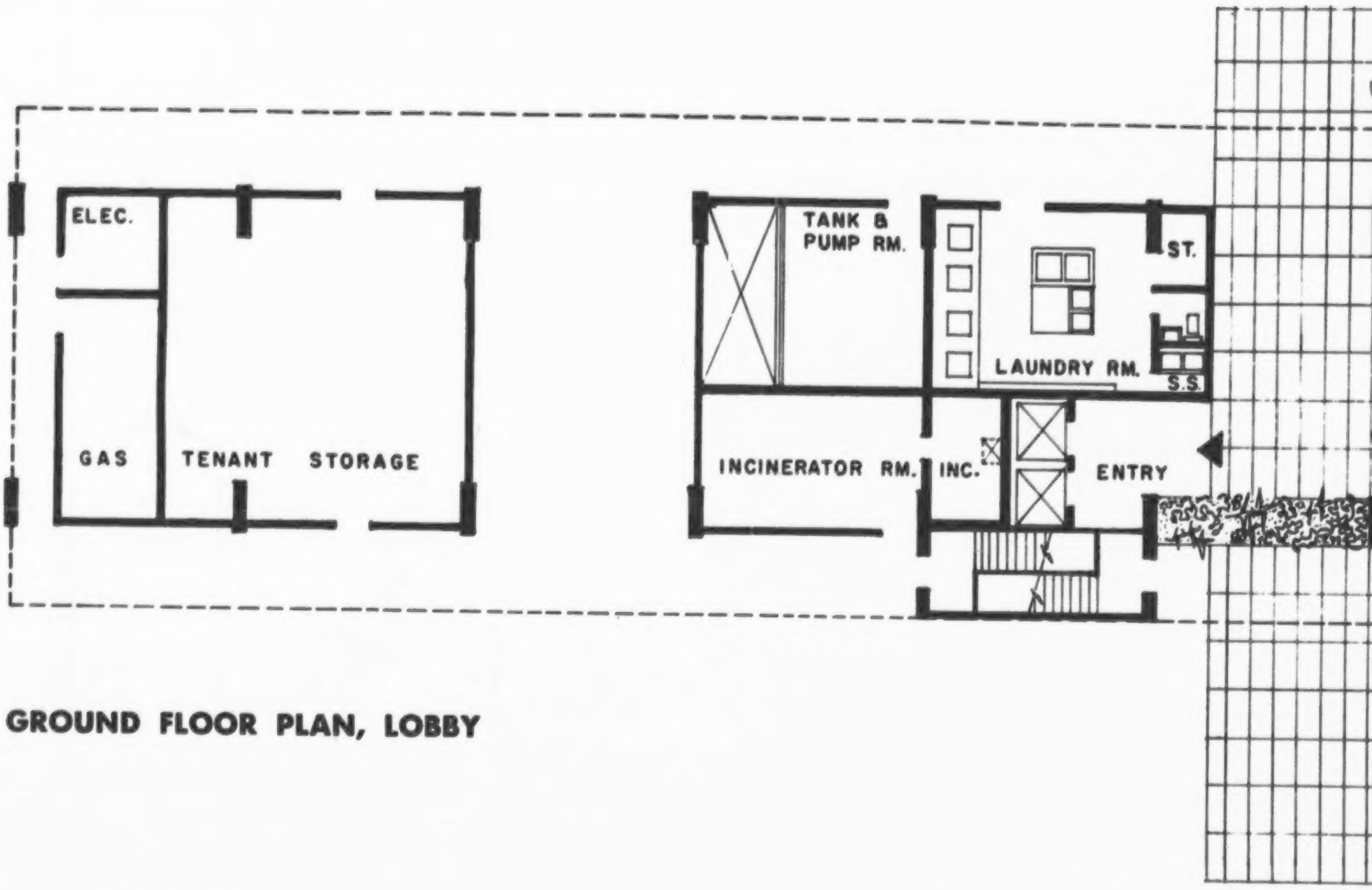
3 INTERIOR-CORRIDOR SCHEME

The interior-corridor scheme is now in common use for low and middle-income housing. It is a simple and economical scheme, permitting ten to twelve apartments per floor. It does not, however, provide cross-ventilation except for the four corner apartments. In New York City public housing, the requirement of cross-ventilation for all apartments having more than one bedroom has produced a variation of this scheme in which the service core forms a "pinched waist" which permits the four adjacent apartments to meet the technical requirements for cross-ventilation. Since in practice the improvement in the ventilation of these four apartments is slight, if any, and the cost of providing it is considerable, this requirement has been ignored in the example presented in the following pages. It is believed that if cross-ventilation is to be considered a primary value, then the open-corridor or the tower scheme should be used rather than the interior-corridor scheme.

Like the other examples in this Chapter the interior-corridor scheme is shown with no basement, with regular column spacing, and with the full distribution of apartment types in a single building. In common with the open-corridor scheme, it employs a two-column bay with cantilevered floor slabs, a structural system which is discussed further in Chapter Two.

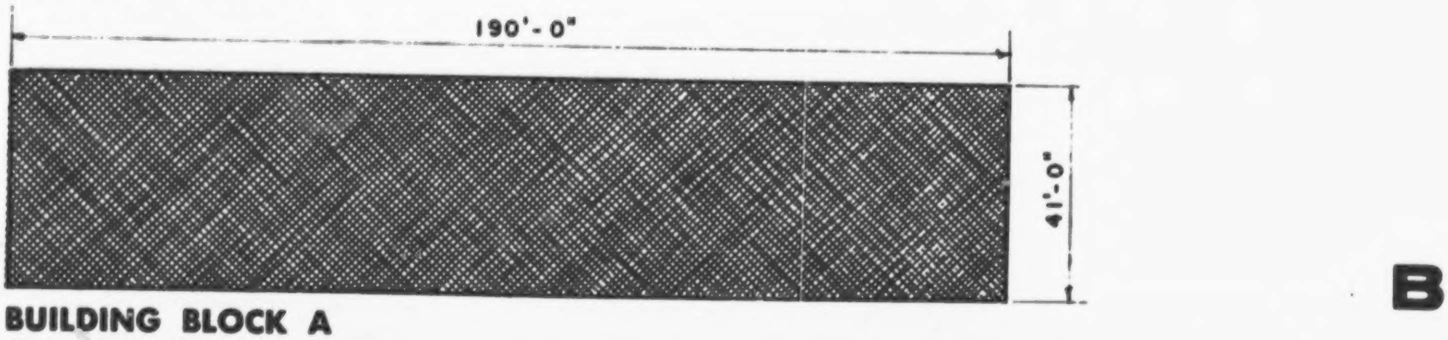
The ground floor plan of the building is shown at the right. Since there is no basement, the facilities usually found there have been located above ground. The remainder of the ground floor has been left open to provide useful covered space and pleasant vistas through the building.

The main purpose of the interior-corridor scheme as presented here is to study the suggestion that the living room might be used also for sleeping. The reasons for considering this idea are discussed in the following pages, along with the suggested planning solutions for putting it into effect. If this idea should be considered feasible from the point of view of livability, the cost savings would be very appreciable, since one bedroom would be eliminated from each apartment. The reduction in area is shown graphically at the right.

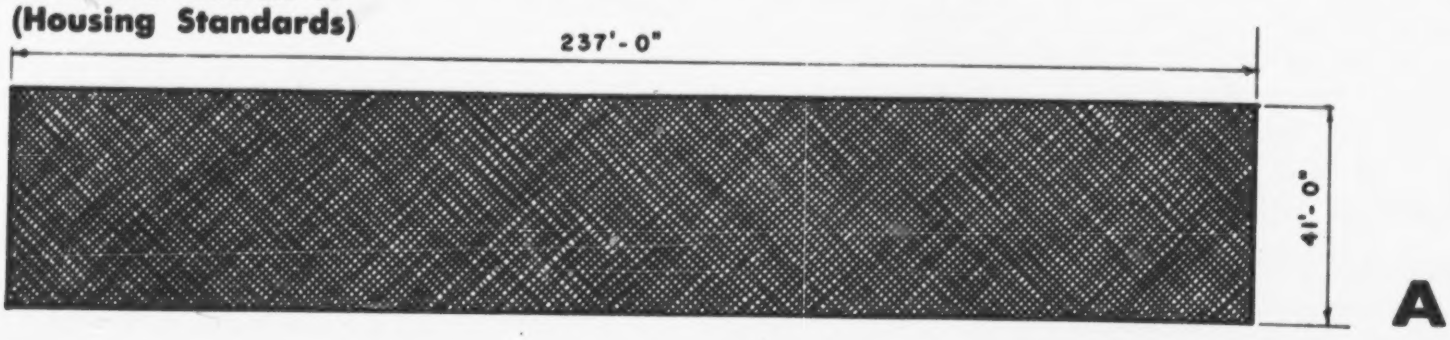

ELEC.
GAS
TENANT STORAGE
TANK & PUMP RM.
LAUNDRY RM.
ST.
S.S.
INCINERATOR RM.
INC.
ENTRY

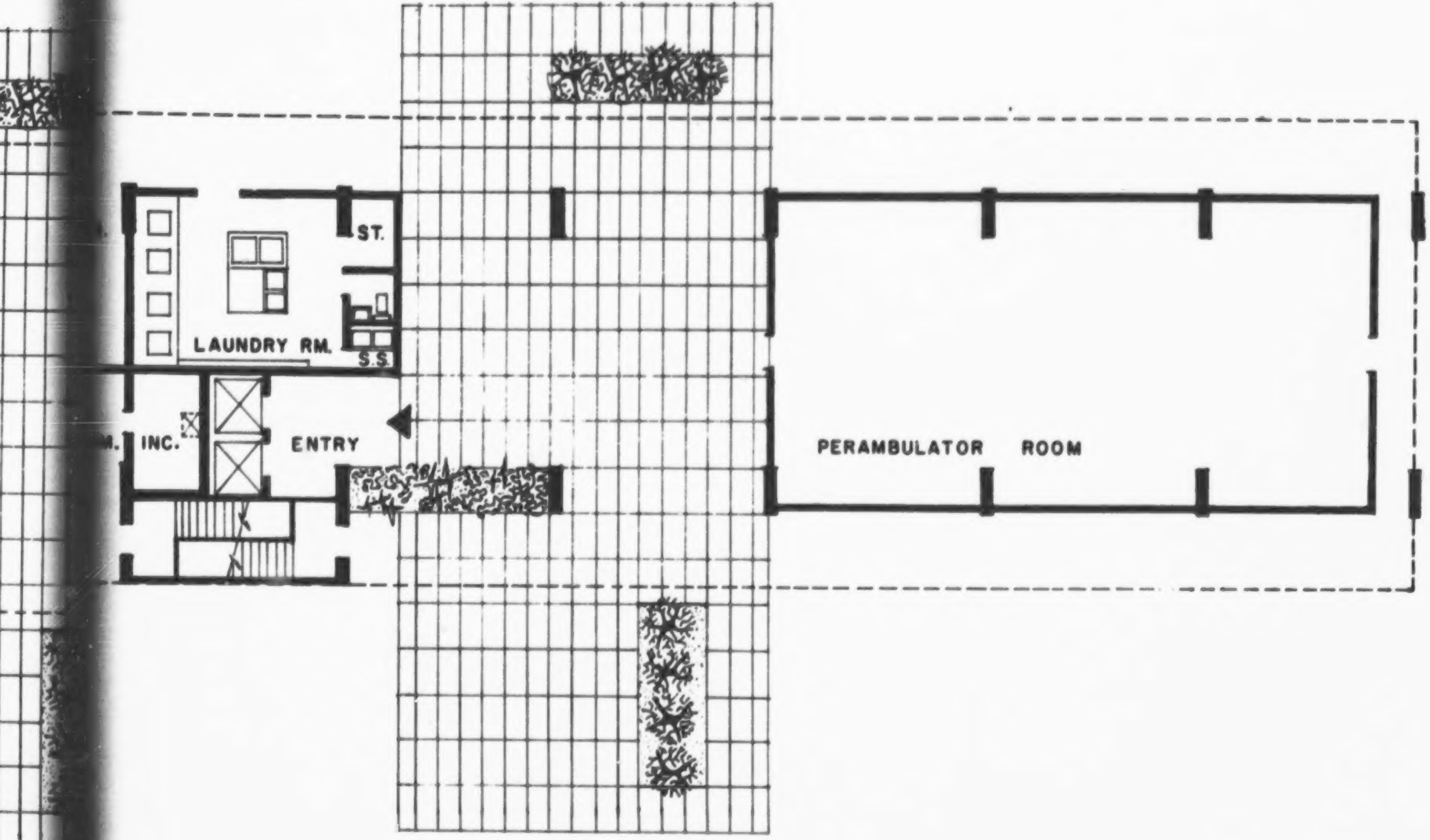
GROUND FLOOR PLAN, LOBBY

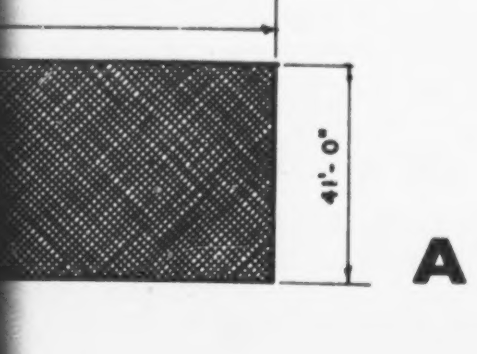
BUILDING BLOCK B
(As per this study)



BUILDING BLOCK A
(Housing Standards)

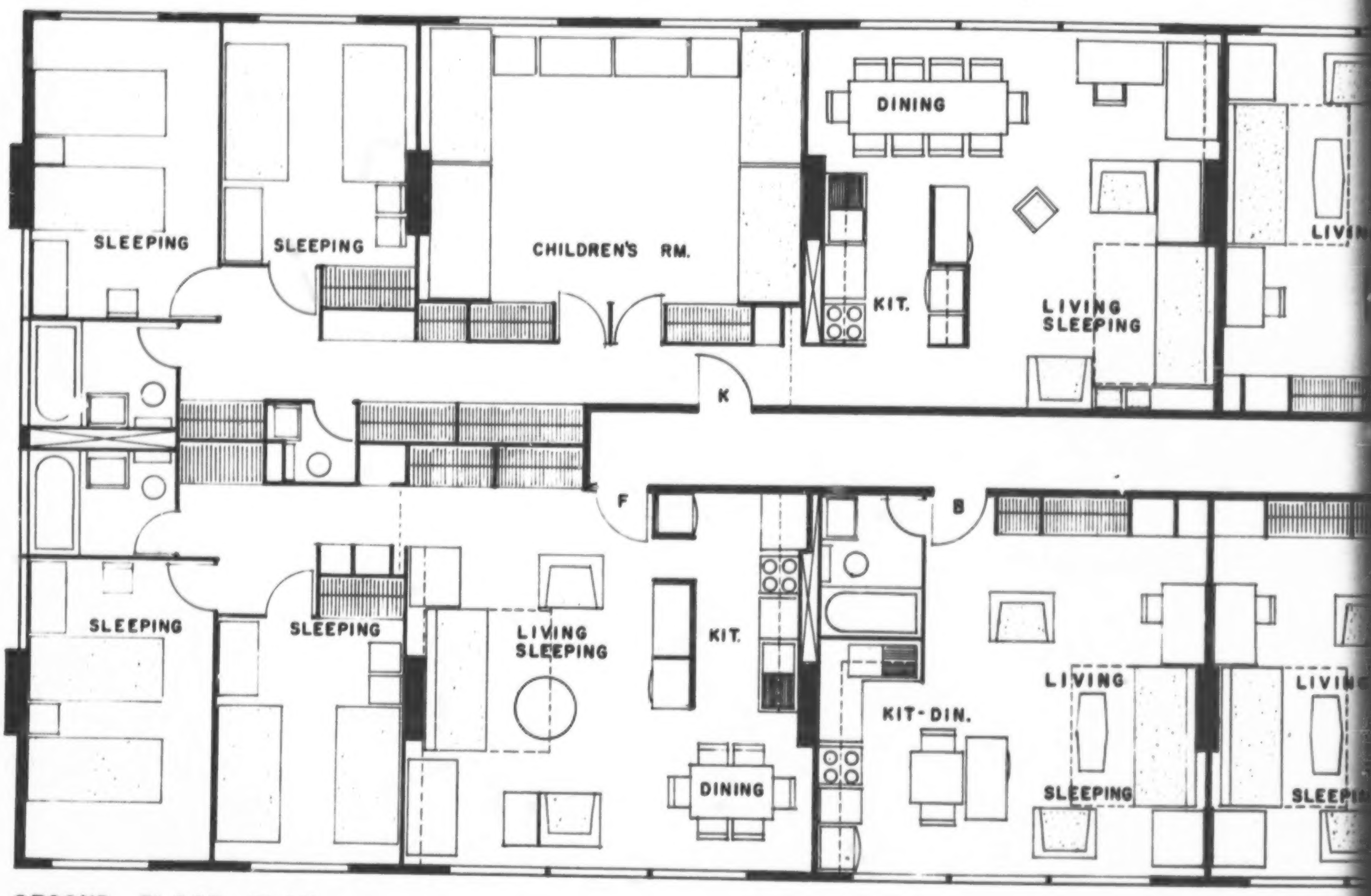






The lower block shows the size of the building designed according to usual housing standards. The upper block shows, at the same scale, the size of the building designed for this study. The reduction in length is 47 feet and the saving in floor area is 1927 square feet, or approximately 20%. The reduction in cost would be somewhat less than 20% since plumbing, kitchen equipment, and elevators are not affected, but the saving should amount to more than 15% of the cost of the building.

INTERIOR-CORRIDOR SCHEME


SLEEPING
SLEEPING
CHILDREN'S RM.
DINING
KIT.
LIVING SLEEPING
LIVI
K
F
B
SLEEPING
SLEEPING
LIVING SLEEPING
KIT.
DINING
KIT-DIN.
LIVING SLEEPING
LIVI
SLEEPI
0 2 4 6 8
SCALE FT

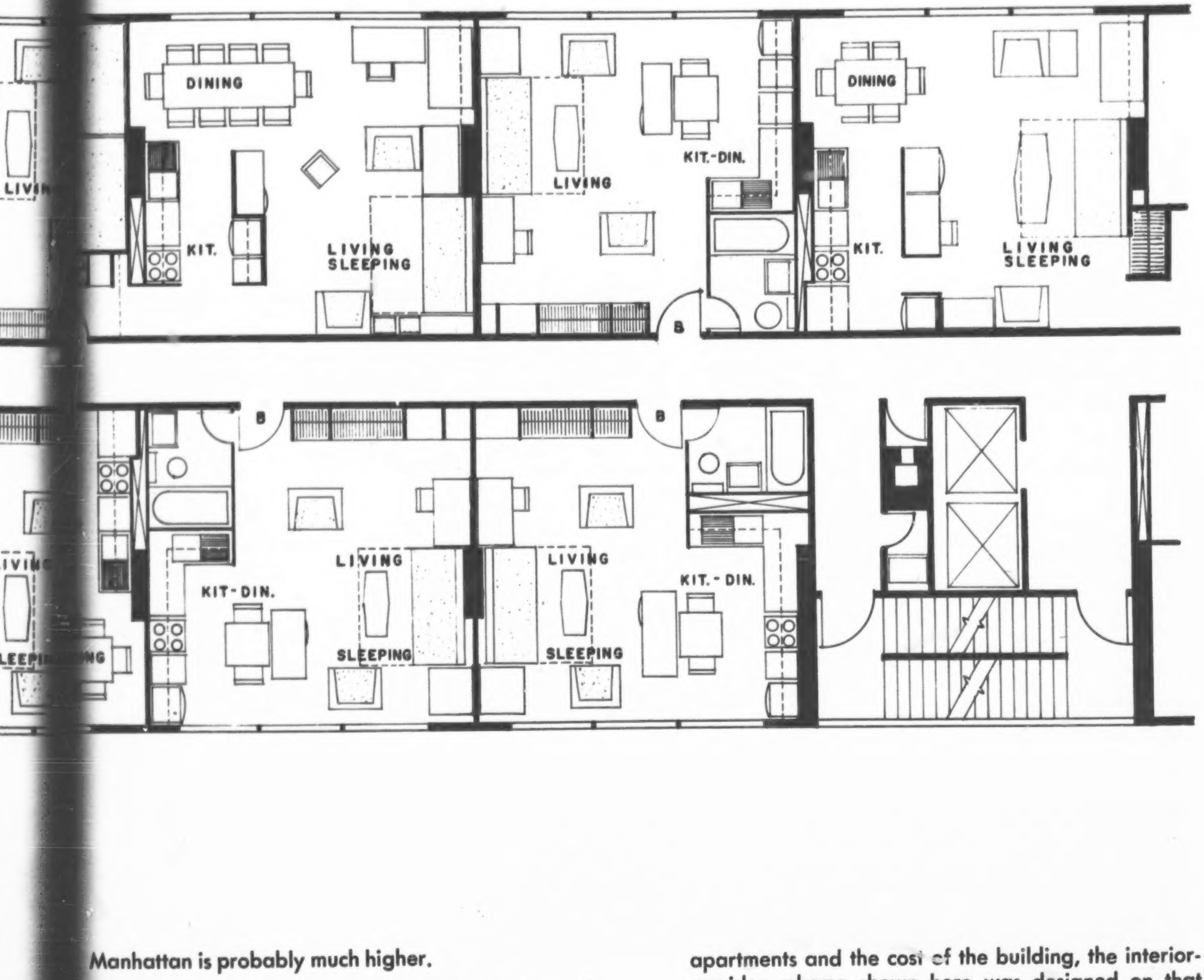
SECOND FLOOR PLAN

It is a matter of common observation that many families in New York regularly use the living room for sleeping. This is a common practice, not just in overcrowded slum areas, but in middle and even upper income apartments. A survey by Pratt Institute of middle-income housing in Brooklyn showed that about 25% of the families regularly used the living room for sleeping. The actual percentage may well be higher than 25%, since many people seemed to be hesitant about admitting it. The percentage in Manhattan is probably much higher.

Presumably this situation is the result of economic pressure; it seems unlikely that many people would choose to live in this manner. But since such a large percentage of New York families do live that way, it raises a question as to whether tax-supported public housing is justified in maintaining a higher standard.

In order to study the effect that the use of the living room for sleeping would have on the livability of the

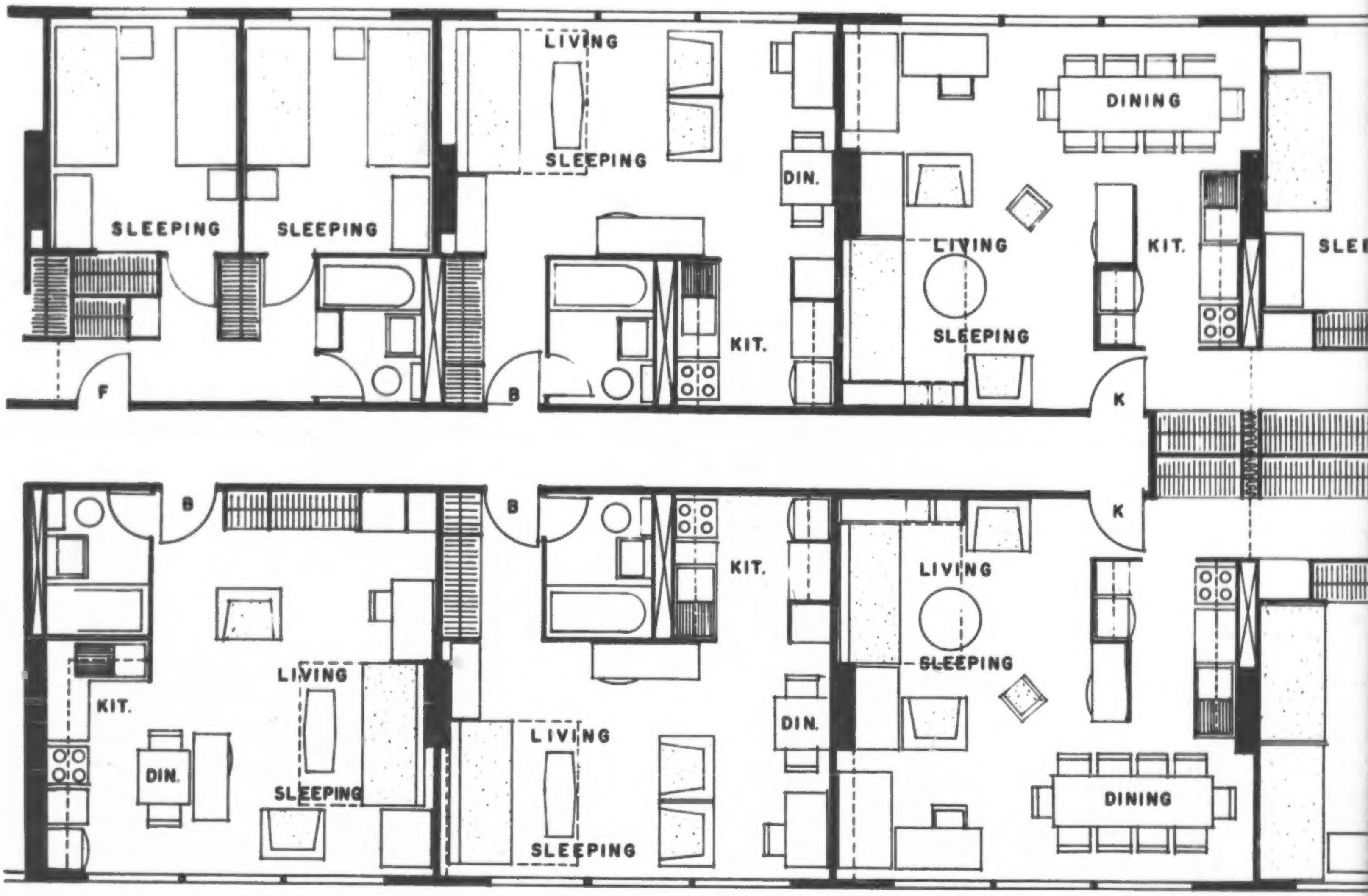
INTERIOR-CORRIDOR SCHEME

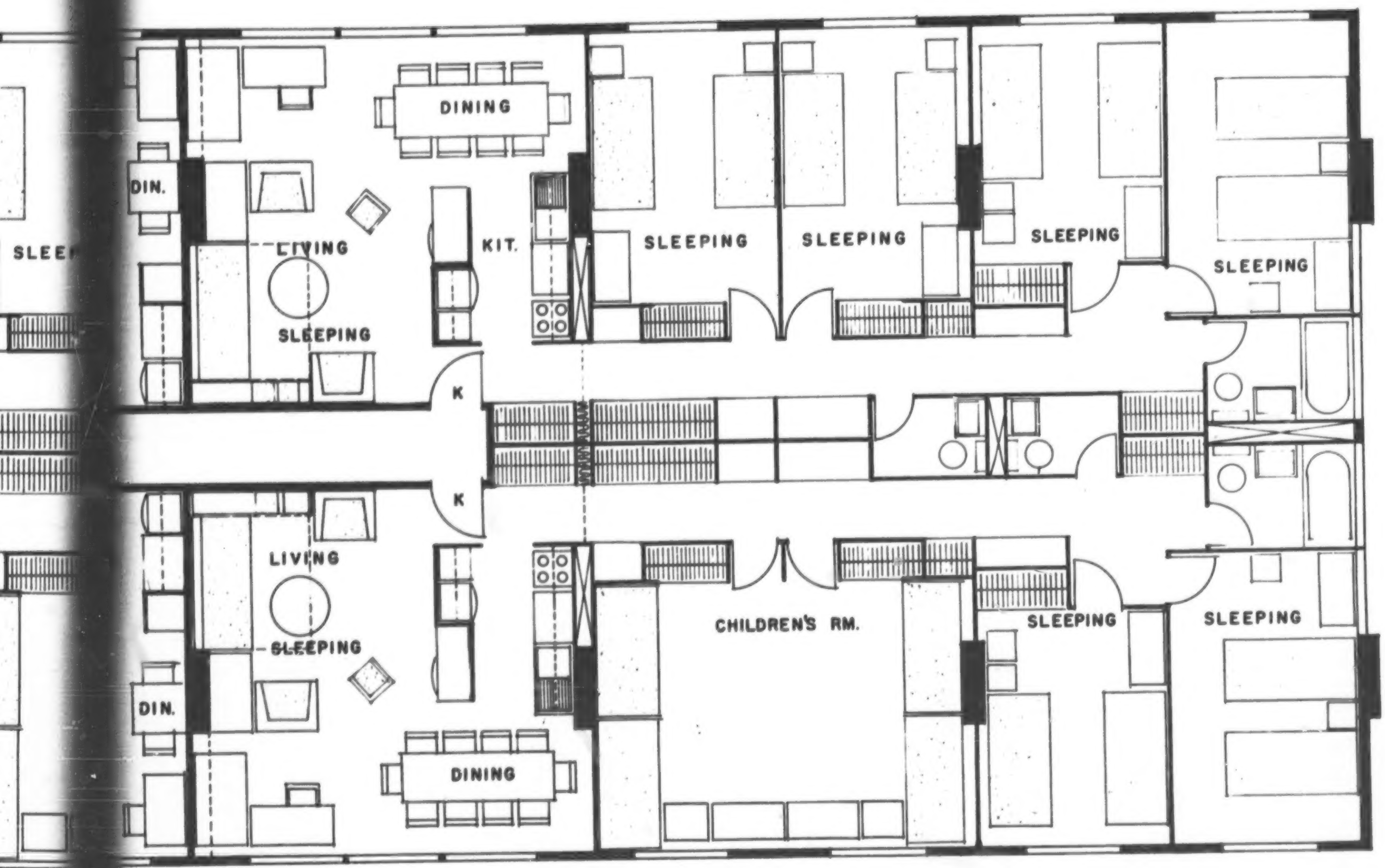

DINING
KIT.
LIVING
SLEEPING
LIVING
KIT.-DIN.
B
DINING
KIT.
LIVING
SLEEPING
B
B
KIT-DIN.
LIVING
SLEEPING
LIVING
SLEEPING
KIT. - DIN.

Manhattan is probably much higher.

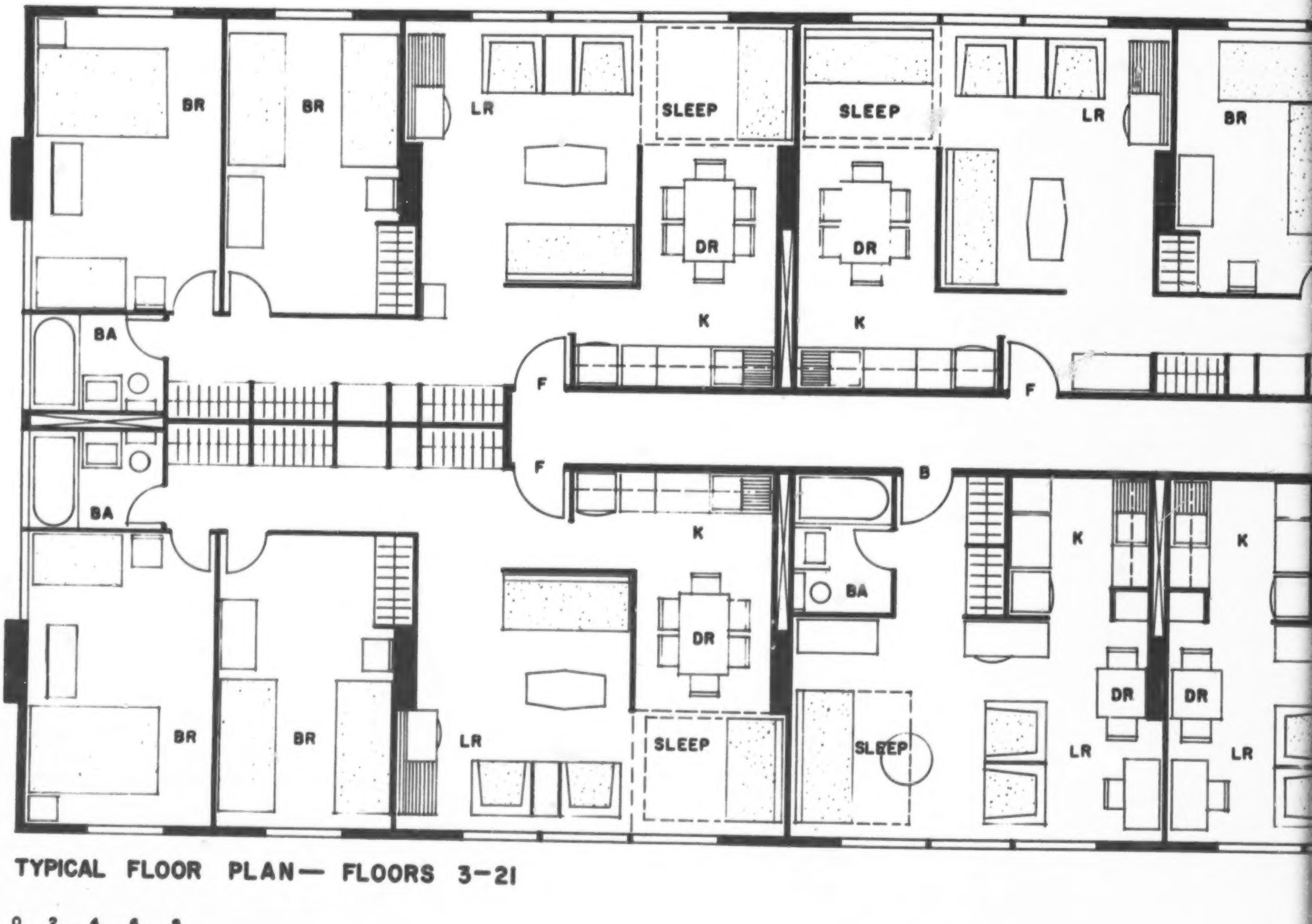
Presumably this situation is the result of economic pressure; it seems unlikely that many people would choose to live in this manner. But since such a large percentage of New York families do live that way, it raises a question as to whether tax-supported public housing is justified in maintaining a higher standard.

In order to study the effect that the use of the living room for sleeping would have on the livability of the apartments and the cost of the building, the interior-corridor scheme shown here was designed on that basis. An alcove for sleeping is provided in each apartment between the living and dining spaces. When not in use for sleeping the alcove is part of the living-dining area and the folding bed provides an additional seating unit. At night the bed is opened up and, if desired, curtains can be pulled to give complete privacy to the sleeping alcove, which has its own window.


SLEEPING
SLEEPING
LIVING
SLEEPING
DIN.
KIT.
DINING
LIVING
SLEEPING
KIT.
SLE
F
B
K
K
B
B
KIT.
LIVING
SLEEPING
KIT.
LIVING
SLEEPING
DIN.
LIVING
SLEEPING
DIN.
DINING


DINING
DIN.
SLEEP
LIVING
SLEEPING
KIT.
SLEEPING
SLEEPING
SLEEPING
SLEEPING
K
K
LIVING
SLEEPING
DIN.
DINING
CHILDREN'S RM.
SLEEPING
SLEEPING

INTERIOR-CORRIDOR SCHEME



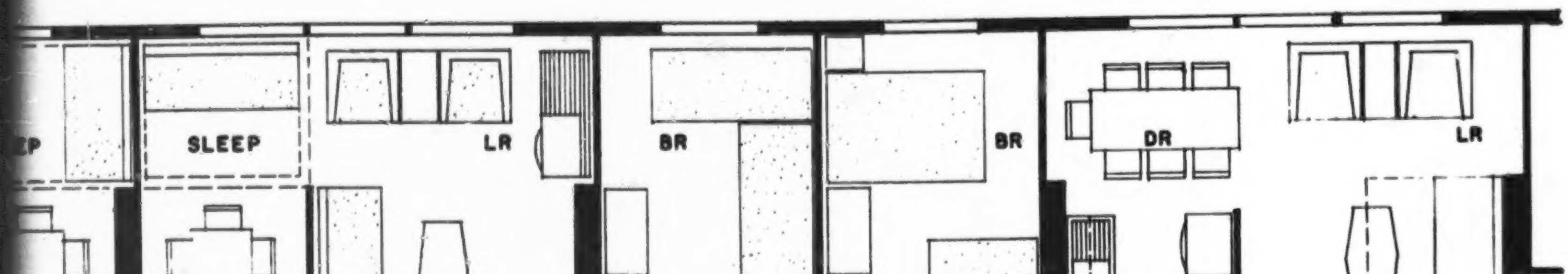
TYPICAL FLOOR PLAN— FLOORS 3-21

Access to the bathroom is possible without going through the living room. Clothes are stored in a closet provided in the hall and in a dresser assumed to be located in the living room.

The plan shown here was designed on the basis of the room sizes required for low-income housing in New York, except that one bedroom has been omitted from each apartment. It demonstrates, it is believed, that the idea is feasible. If this proposal is considered to be worthy of further study, it is suggested that the living rooms be increased slightly in size and that a closet or a recess (they are the same thing in public housing) be provided in the hall for a chest of drawers.

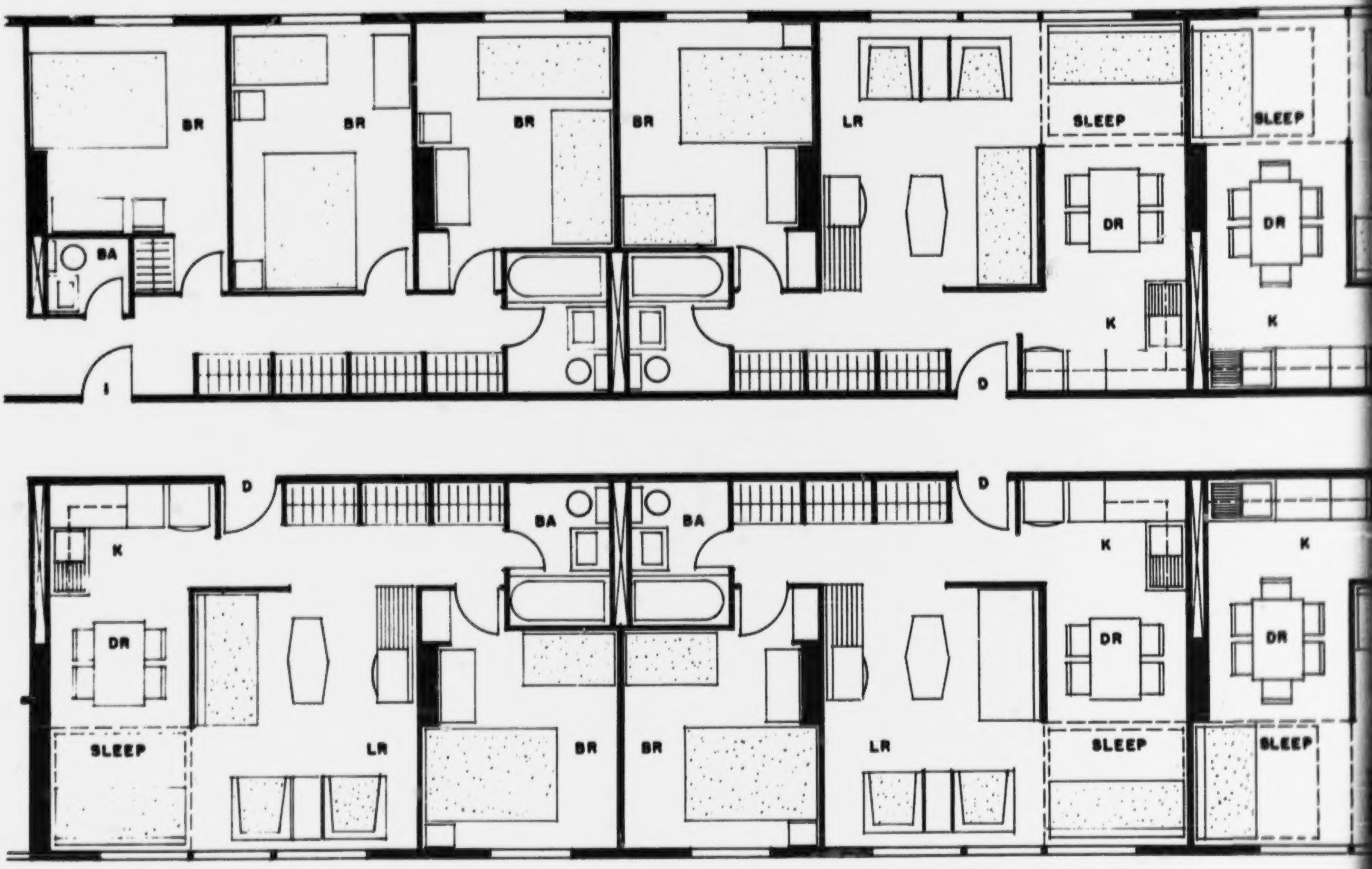
Any family with five or more children is likely to have three or four children of the same sex who are near enough in age to share amicably one large bedroom. Although there is some economy in such an arrangement the principal advantage is in improved livability, the combined room being large enough to provide usable play space for the children. Such an arrange-

INTERIOR-CORRIDOR SCHEME



living rooms be increased slightly in size and that a closet or a recess (they are the same thing in public housing) be provided in the hall for a chest of drawers.

Any family with five or more children is likely to have three or four children of the same sex who are near enough in age to share amicably one large bedroom. Although there is some economy in such an arrangement the principal advantage is in improved livability, the combined room being large enough to provide usable play space for the children. Such an arrangement is shown in two of the three large apartments in the plan above. If a folding partition were provided it would give families the choice of using the space as one room or two. Although not shown here, it would be possible to reduce the size of such a dormitory bedroom somewhat below that of two separate bedrooms. But the cost saving would not be great since there are relatively few (10%) large apartments in a project.


BR
BR
BR
BR
LR
SLEEP
SLEEP
BA
DR
DR
K
K
I
D
D
BA
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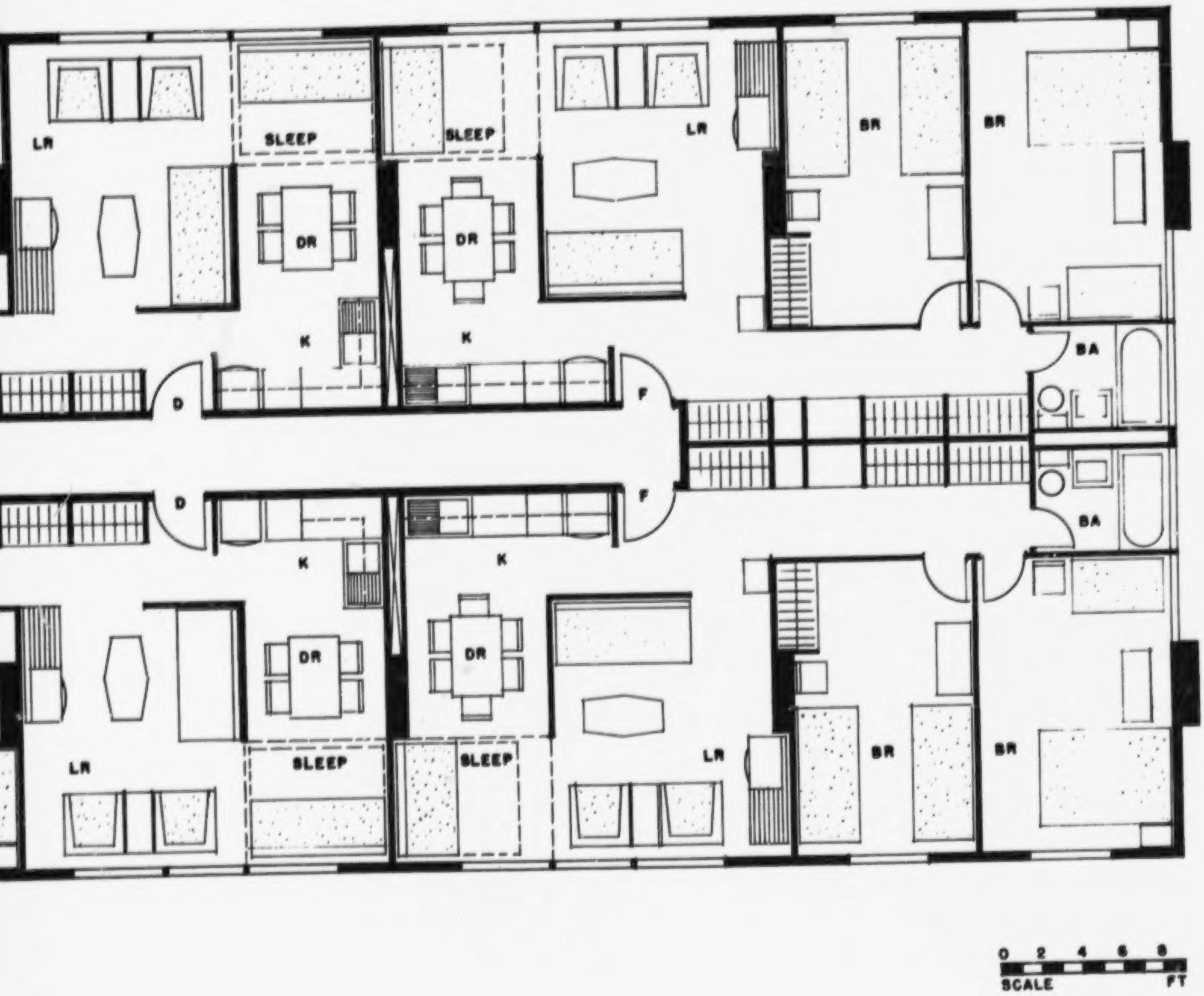
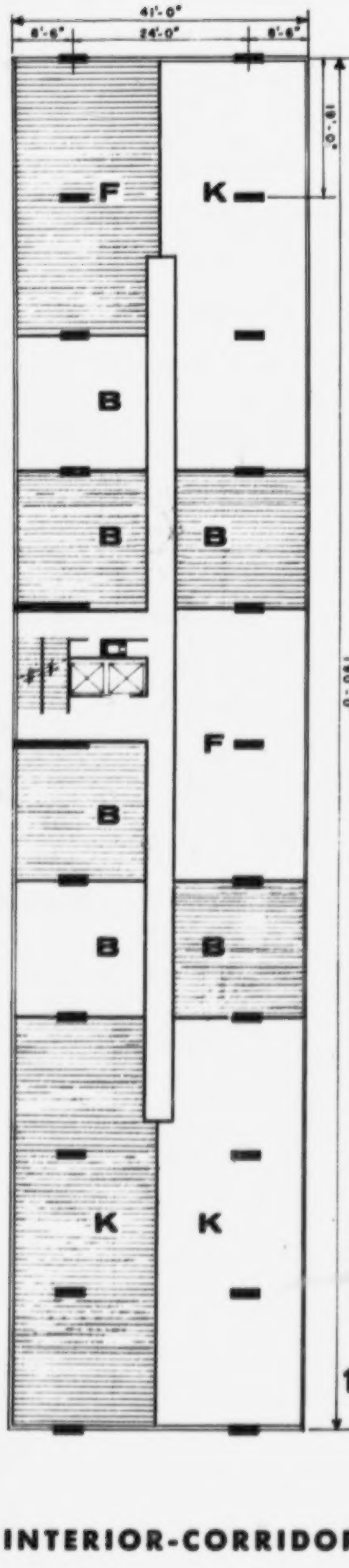
D
K
K
K
DR
DR
DR
SLEEP
LR
BR
BR
LR
SLEEP
SLEEP

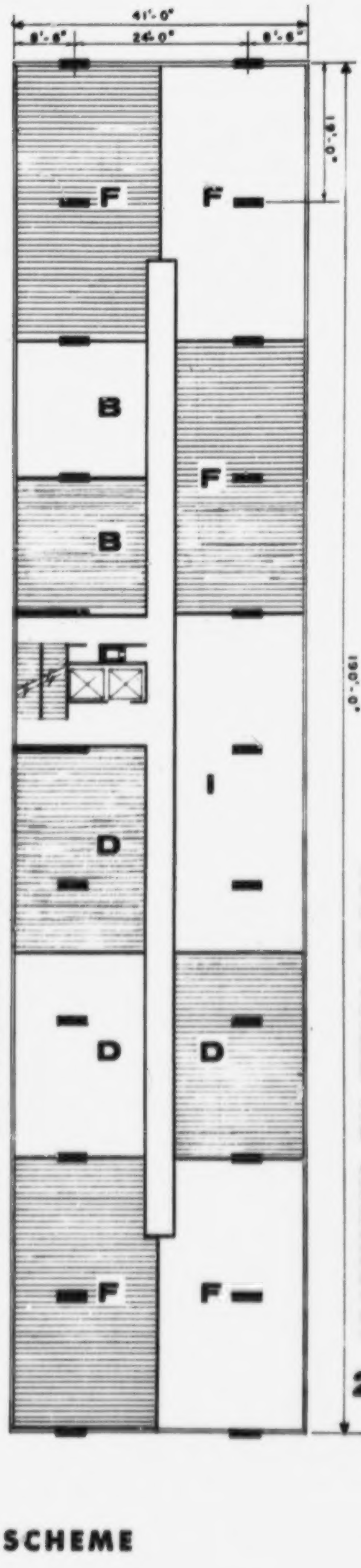
2


LR
SLEEP
SLEEP
LR
BR
BR
DR
DR
K
K
BA
D
F
D
F
BA
K
K
DR
DR
LR
SLEEP
SLEEP
LR
BR
BR
0 2 4 6 8
SCALE FT

INTERIOR-CORRIDOR SCHEME


41'-0"
8'-6"
24'-0"
8'-6"
19'-0"
190'-0"
F
K
B
B
B
F
B
B
B
K
K

1 APARTMENTS ON SECOND FLOOR


41'-0"
8'-6"
24'-0"
8'-6"
19'-0"
190'-0"
F
F
B
F
B
I
D
D
D
F
F

2 APARTMENTS ON TYPICAL FLOOR

INTERIOR-CORRIDOR SCHEME

Th
be
of

No. of rooms per apa
Occupants per apartm
Apartments per typ. fl
Total apts. for 19 floo
Apartments on 2nd flo
Total apts. per buildin

Distribution by %
Required distribu

DATA PER APA

LETTER CONST. R

B..........2.
D...........3.
F..........4.
I..........5.
K..........6.

Th
ro
pl
20
te

The required distribution of apartment types has been provided within a single building. The schedule of distribution is as follows:

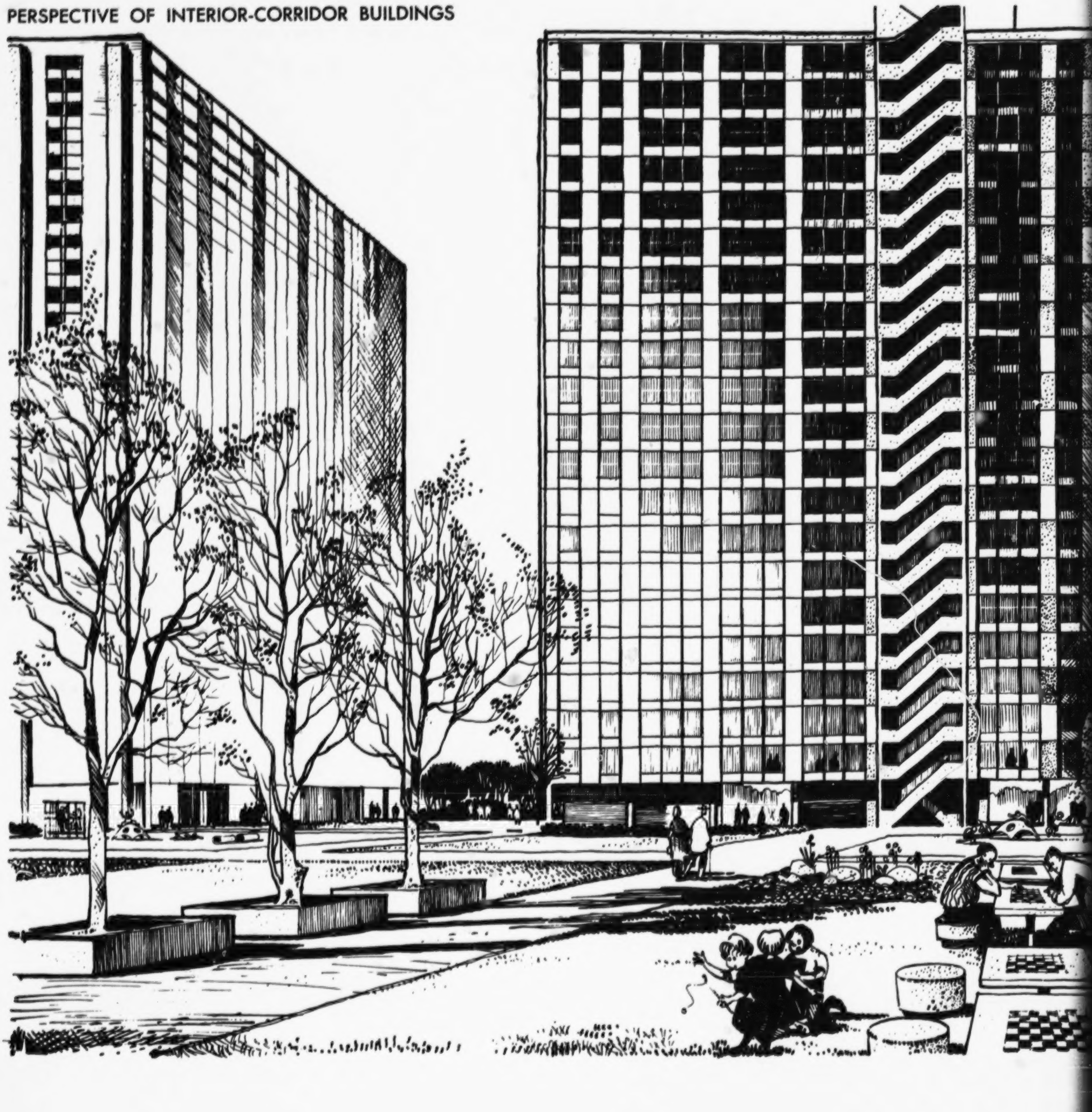
No. of rooms per apartment	2	3	4	5	6	Total
Occupants per apartment	2	3	5	7	9	–
Apartments per typ. floor	2	3	5	1	—	11
Total apts. for 19 floors	38	57	95	19	—	209
Apartments on 2nd floor	6	—	2	—	3	11
Total apts. per building	44	57	97	19	3	220
Distribution by %	**20.0**	**25.9**	**44.1**	**8.6**	**1.4**	**100.0**
Required distribution	**20.0**	**25.0**	**45.0**	**8.5**	**1.5**	**100.0**

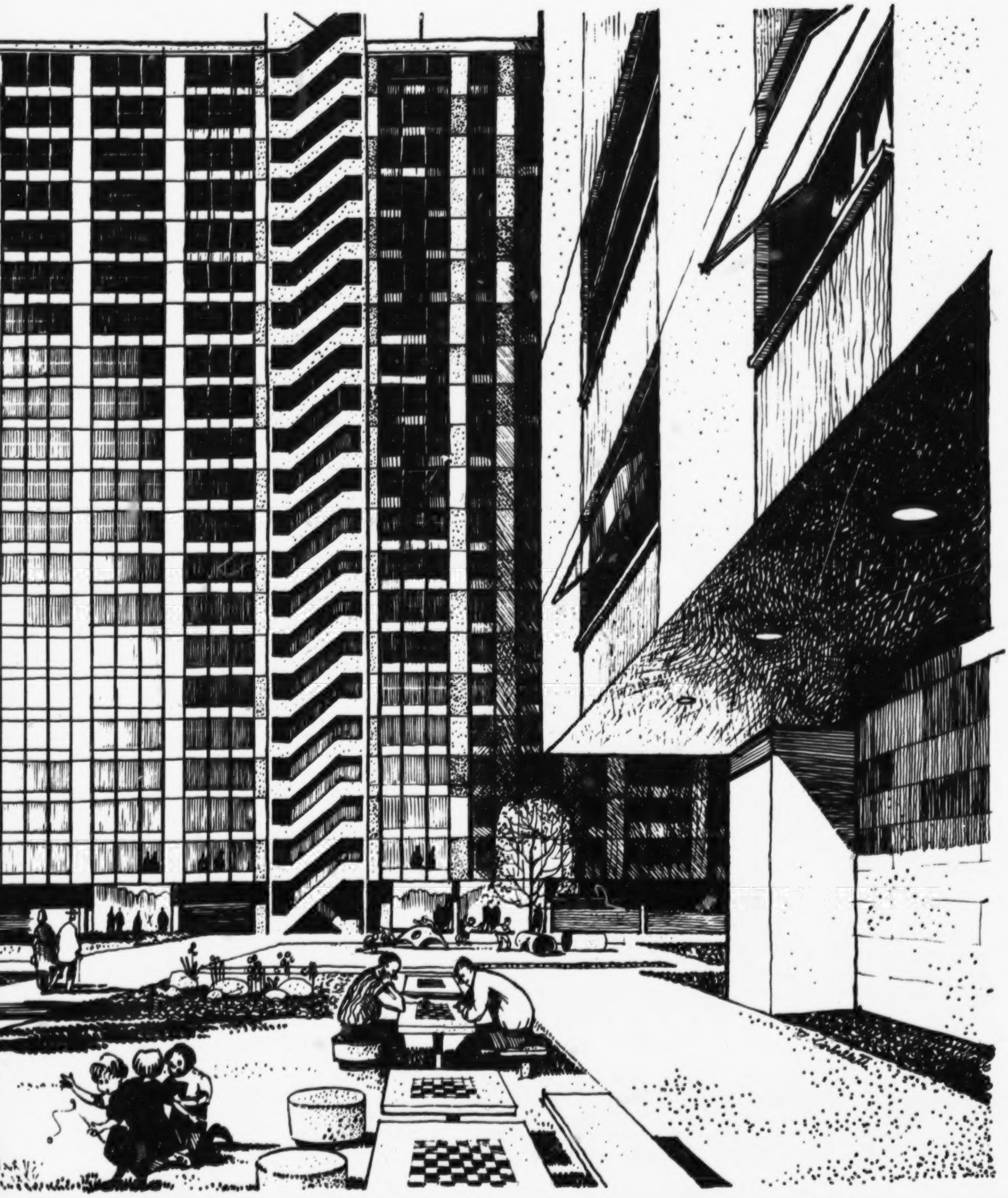
DATA PER APARTMENT:

LETTER	CONST. ROOMS	RENTAL ROOMS	OCCUPANCY
B	2	2½	2
D	3	3½	3
F	4	5½	5
I	5	6½	7
K	6	7½	9

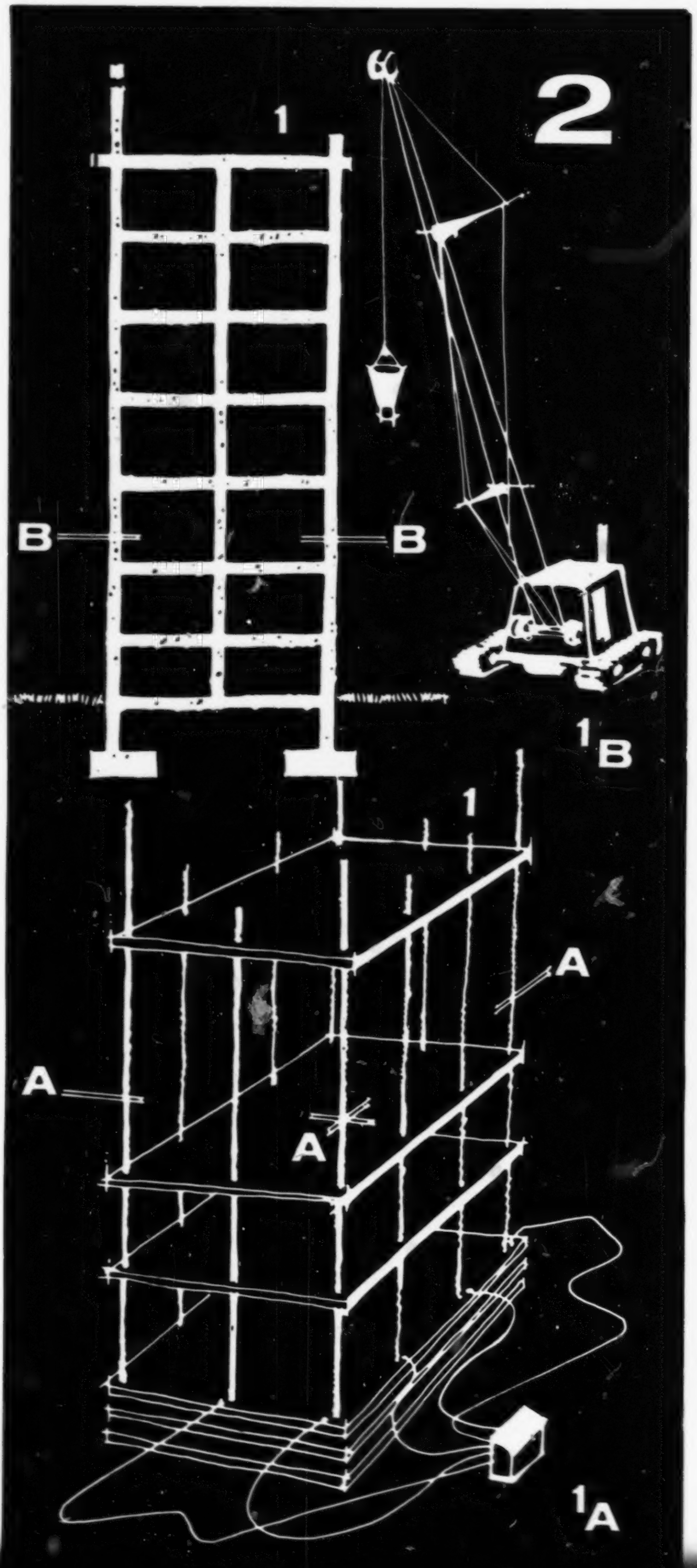
There are a total of 760 construction rooms or 870 rental rooms for an average occupancy of 904 people. The average gross area per construction room is 205 square feet and the average length of the exterior wall per construction room is 12.15 feet.

PERSPECTIVE OF INTERIOR-CORRIDOR BUILDINGS





INTERIOR-CORRIDOR SCHEME


2
1
B
B
1B
1
A
A
A
1A

CHAPTER TWO — STRUCTURAL SYSTEMS

Of the many possible ways of framing a building, five methods which appeared to offer the greatest promise of effecting economies, immediately or in the near future, were selected for detailed study. They range from the old and very familiar to the new and less familiar. None can be called experimental; all have been extensively and successfully used, either in this country or abroad.

The system of construction now used almost universally in New York City for public housing is reinforced concrete flat plate with "spattered" columns. As discussed in the previous Chapter, the spattered column arrangement has resulted largely from the rigid planning requirements imposed by the government housing agencies. If these requirements were to be relaxed, the economies which are inherent in regular column spacing, regardless of the material or method of construction used, could be realized in public housing. Thus all of the structural studies presented here assume regular spacing of the structural elements.

The study begins with a consideration of two variations of the presently used flat plate reinforced concrete system. Then attention is directed to a precast concrete system and to modern light-steel framing. Finally a new look is taken at an old stand-by — non-fireproof masonry bearing wall construction. Brief descriptions of the five structural systems discussed in this Chapter follow:

1. **Two-Column Cantilever System.** A reinforced concrete flat plate construction having only two longitudinal rows of columns instead of the usual four. Floor slabs cantilever out beyond each row of columns and support the walls, which should obviously be as light in weight as possible. The prospect of only half as many columns and foundations seemed likely to result in overall economy, a supposition which was strengthened by the selection, after long study, of this system of construction for use in the Statler Hilton Hotel in Dallas, Texas.
2. **Lift-Slab Construction.** Reinforced concrete flat plate floor slabs poured on the ground one on top of another, and lifted into place by the patented "lift-slab" technique. Columns are assumed to be steel, but may be precast concrete. This relatively new system of construction has proven to be more economical than poured-in-place construction for many types of building in all areas of the country. There appears to be no reason why New York City housing should not take advantage of its proven economies.
3. **Box-Frame Construction.** A frameless construction of precast concrete slabs, applied both horizontally and vertically. Wall, partition, and floor slabs are cast on the ground and lifted into place by crane. Little used as yet in this country, this system of construction has been extensively used in Europe. By eliminating all columns and beams, and most of the formwork and scaffolding, it seems likely to effect notable economies.
4. **Light-Steel Framing.** The use of bar-joists, junior beams, and cold-rolled sections has proved to be more economical than reinforced concrete construction in many cities. The selection, after thorough study, of light steel framing for the forty-building Levitt apartment project in Queens, showed that this system of construction offers economies in New York City too. The reduced weight of the structure indicates the possibility of significant savings in foundation costs, especially where piles are necessary.
5. **Non-Fireproof Construction.** Wood or bar joist floor construction on masonry bearing walls. This type of construction is very widely used in New York City for middle-income housing, and the question is naturally raised as to why it should not be considered suitable for tax-supported low-income housing. Limited by law to a maximum height of six stories, this type of construction might well be used in outlying sections where land values do not necessitate high rise buildings, and also in central areas in conjunction with high rise buildings.

In all cases it should be noted that, in order to obtain the maximum economy from any structural system, the project must be designed from the outset for that system of construction. This fact has been something of a handicap to the present study which has had to take an existing public housing design and adapt it to several types of construction which were being studied. Potential economies may very well be greater than indicated in the following pages.

1 TWO-COLUMN CANTILEVER

The two-column system differs from the usual flat-plate designs used in tall buildings in that there are only two longitudinal rows of columns in the long narrow building and the floor slabs cantilever 8 feet beyond both column centerlines.

Structurally, the double-cantilever design is highly efficient because bending moments at columns and at midspan are nearly equal, resulting in less reinforcing steel and less concrete per slab.

On the following pages we present:

1. Review of current two-column cantilever structures.
2. A comparative structural and cost analysis of two types of reinforced concrete flat plate construction — the two-column cantilever slab and the conventional "spattered-column" or four-column cage system of construction.

Review of Current Structures

"CANTILEVER FLOORS CUT COST OF CONCRETE HOTEL"

"A tough wind-resistance problem had to be solved before savings could be realized with the lightweight-aggregate, flat-plate floors, which support thin, metal-faced walls."

In the Statler-Hilton Hotel in Dallas the flat-plate floors project 10'-0" out from outer columns on all sides

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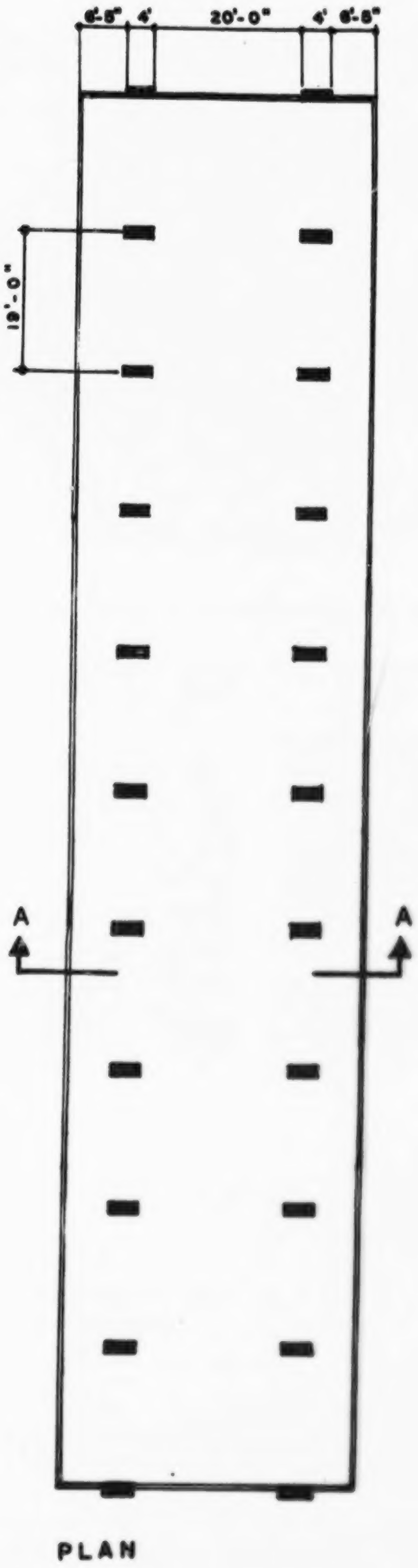
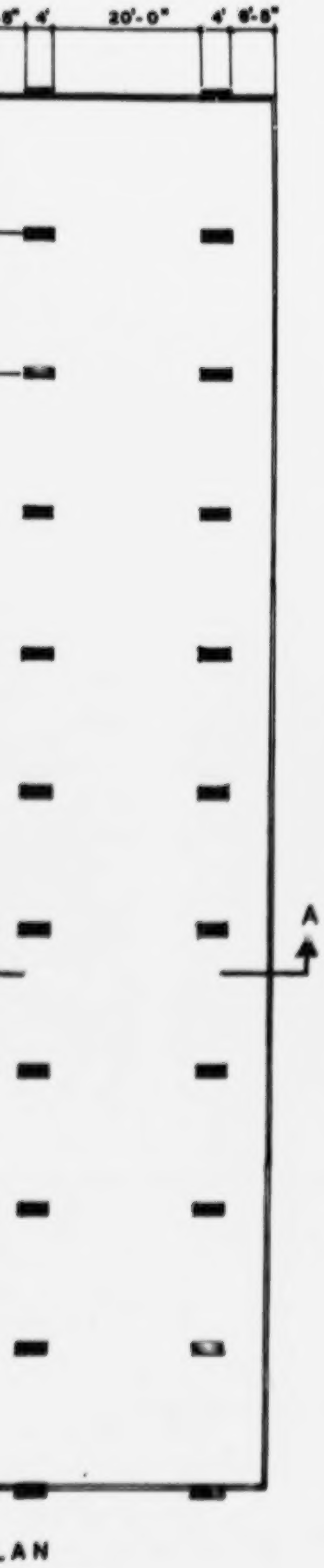

6'-8"
4'
20'-0"
4'
6'-8"
19'-0"
A
A
PLAN

See Interior-Corridor; Chapter One

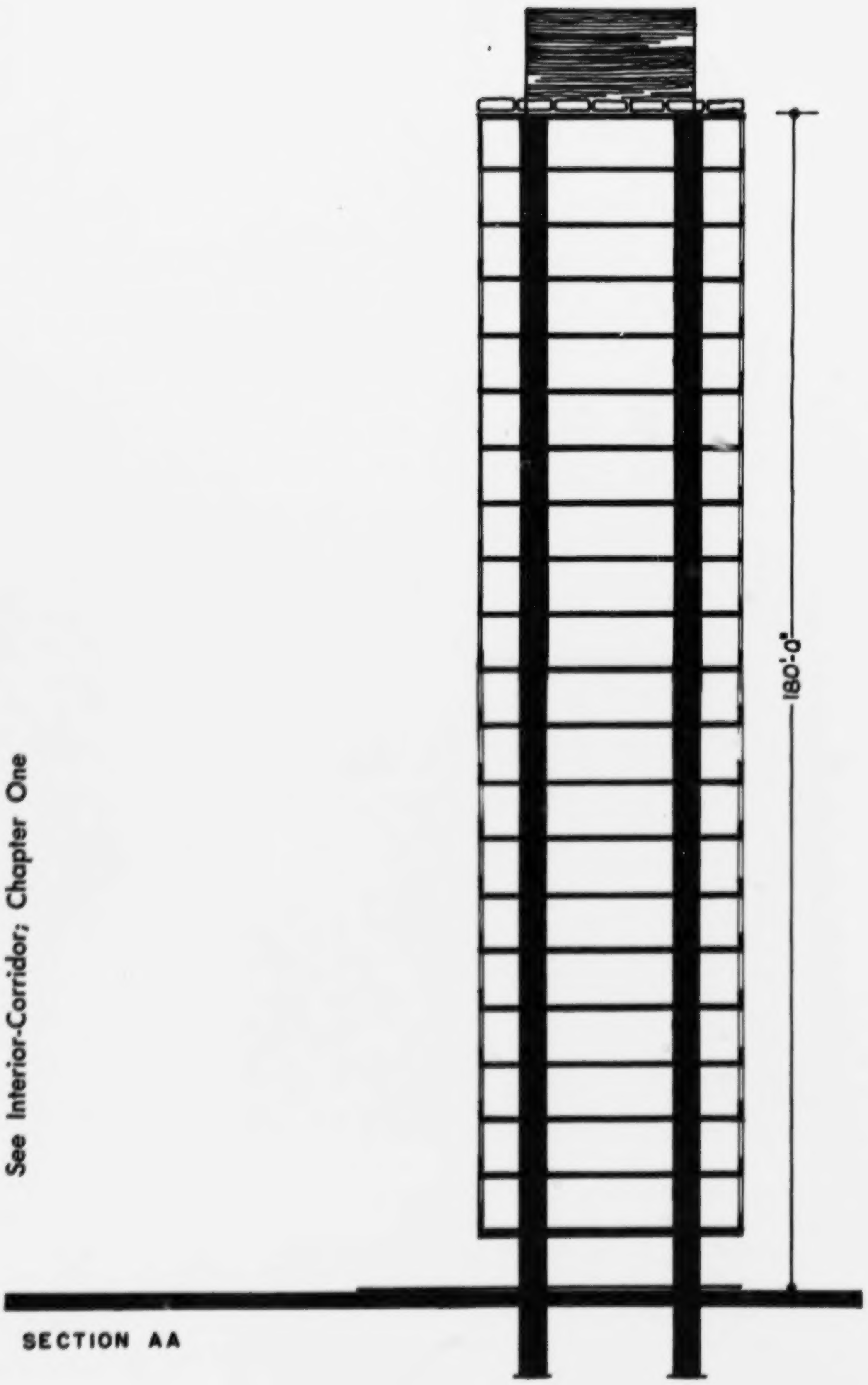
SECTIO

Plan and Section of a two-column cantilever as developed for the Interior-Corridor Scheme of Chapter One of this report.



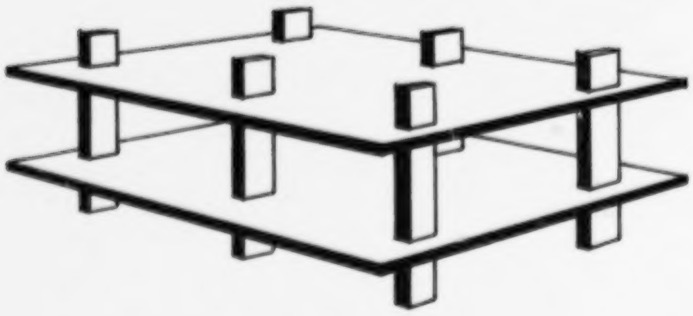
LAN

See Interior-Corridor; Chapter One

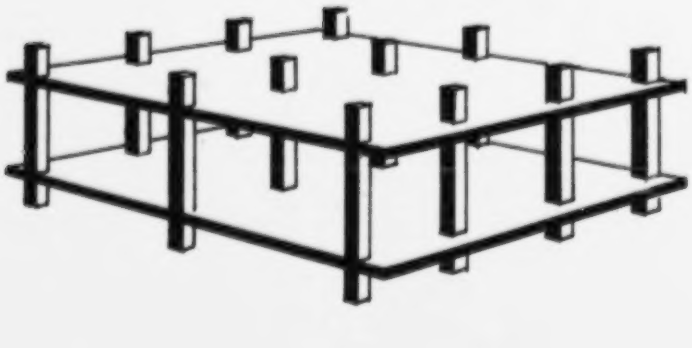


SECTION AA

TWO-COLUMN CANTILEVER



TWO COLUMN CANTILEVER



FOUR COLUMN CAGE

TWO-COLUMN CANTILEVER

photo: Louis Checkman

Statler-Hilton Hotel in Dallas

photo: Louis Checkman

tler-Hilton Hotel in Dallas

Comparative Structural Analysis

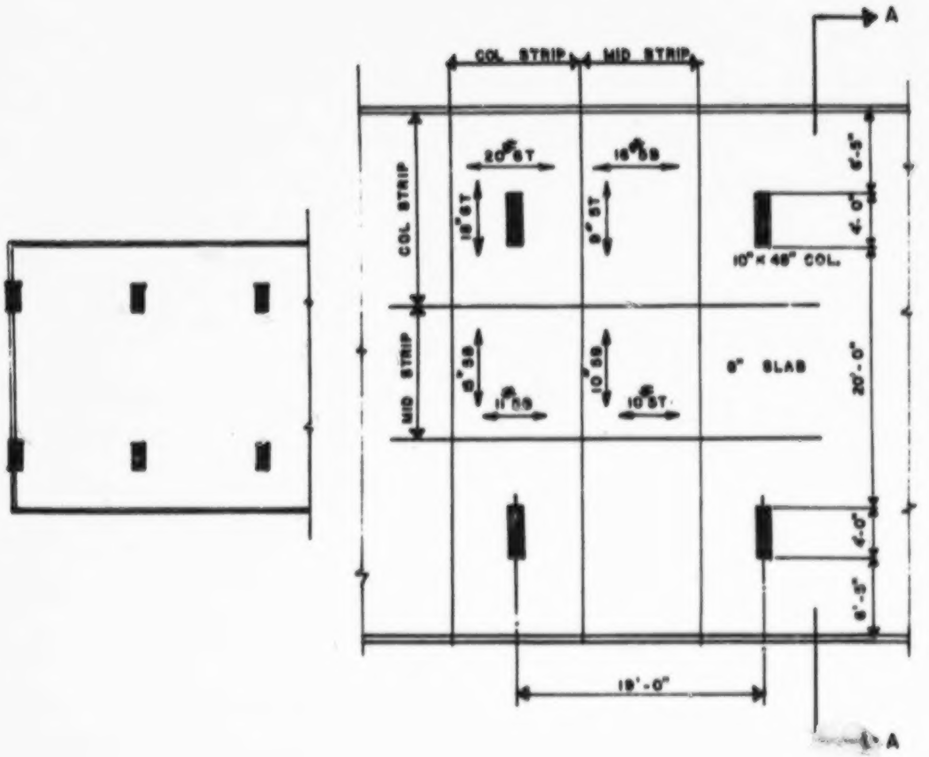
A comparative analysis of the two-column cantilever vs. the four-column cage is presented here in order to investigate the possible use of the two-column system in public housing.

The two-column cantilever system was successfully used in the Statler Hilton Hotel in Dallas, Texas, with an appreciable cost saving over the conventional framing method. Here the slab was cantilevered ten feet beyond the column centerlines to support the light-weight exterior curtain wall. The use of a lightweight concrete aggregate, which was readily available nearby, further helped to reduce the dead weight of the structure and made possible the use of this structural system to its greater efficiency.

The analysis on the following page is a cost comparison of the two-column cantilever system as developed for public housing with a plan type detailed in Chapter One vs. the conventional four-column system, using stone concrete in both cases. The analysis shows that in New York City the four-column type would cost 30c per square foot or 12% less than the two-column cantilever type. However, should lightweight aggregate be competitively available in New York City, it would lower the cost of this system to somewhere near the cost of the conventional type by reducing the dead weight of the structure itself, thereby reducing the amount of reinforcing steel required. Also, if the New York City Building Code would permit the use of the extremely light-weight exterior walls as used in the Dallas Statler Hilton, thereby reducing the concentrated load on the ends of the cantilevered floor slabs, the cost of the two-column system would be substantially reduced.

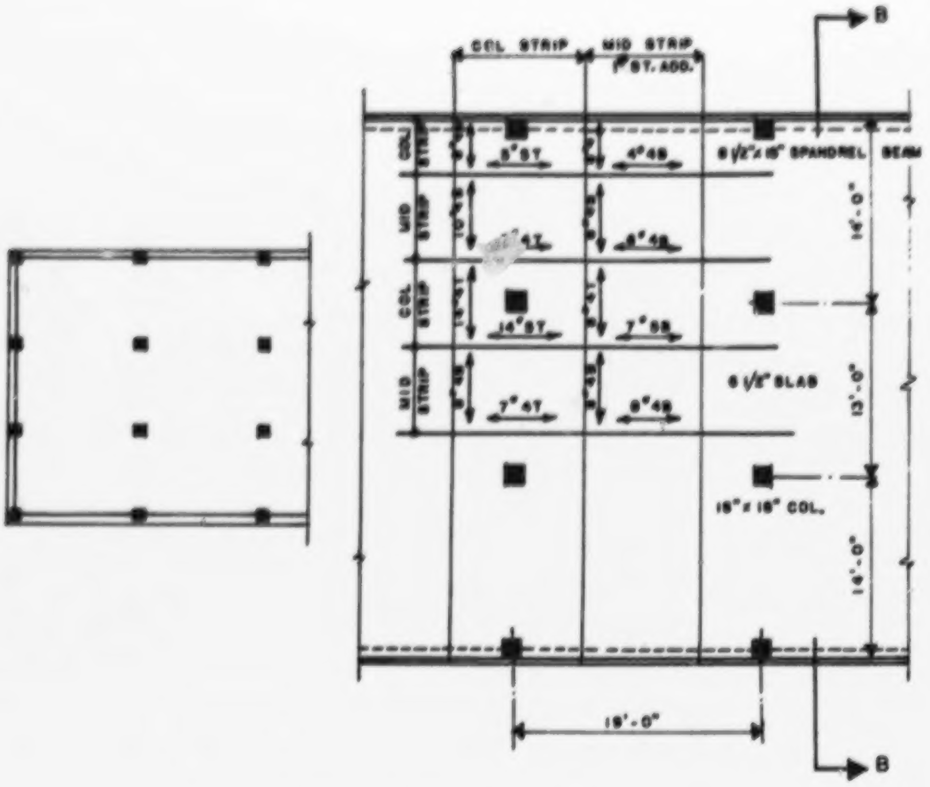
The comparative ease of forming the identical 10" x 48" columns and the reduction in the total number of columns and foundation further suggest a substantial saving in construction time with an accompanying cost saving.

The cost analysis of the two structural systems that follows was completed with the cooperation of the office of Seelye, Stevenson, Value and Knecht, the engineering firm that designed the structure for the Statler Hilton Hotel in Dallas.


A
COL STRIP
MID STRIP
20" ST
16" SB
18" ST
9" ST
10" x 48" COL.
6'-3"
4'-0"
20'-0"
8" SLAB
11" SB
10" ST
10" SB
19'-0"
A

1 TWO COLUMN CANTILEVER

2 FOUR COLUMN CAGE


B
COL STRIP
MID STRIP
1" ST. ADD.
8 1/2" x 16" SPANDREL BEAM
5" ST
4" 4B
14" ST
7" 5B
6 1/2" SLAB
7" 4T
6" 4B
16" x 16" COL.
14'-0"
13'-0"
19'-0"
B

TWO COLUMN CANTILEVER

CONCRETE	$ 515.00
REINFORCING	698.00
FORMS	735.00

COST:
41' x 19' BAY..........$1948.00

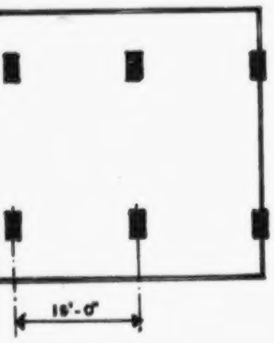
$2.50 PER SQUARE FOOT

FOUR COLUMN CAGE

CONCRETE	$ 445.00
REINFORCING	517.00
FORMS	753.00

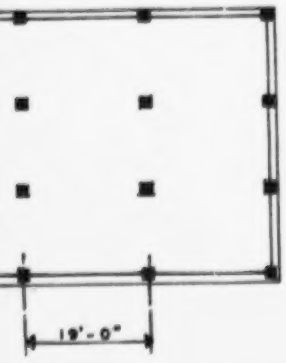
COST:
41' x 19' BAY..........$1715.00

$2.20 PER SQUARE FOOT



TWO COLUMN CANTILEVER

FOUR COLUMN CAGE



TWO COLUMN CANTILEVER

CONCRETE	$ 515.00
REINFORCING	698.00
FORMS	735.00

COST:
41' x 19' BAY..........$1948.00

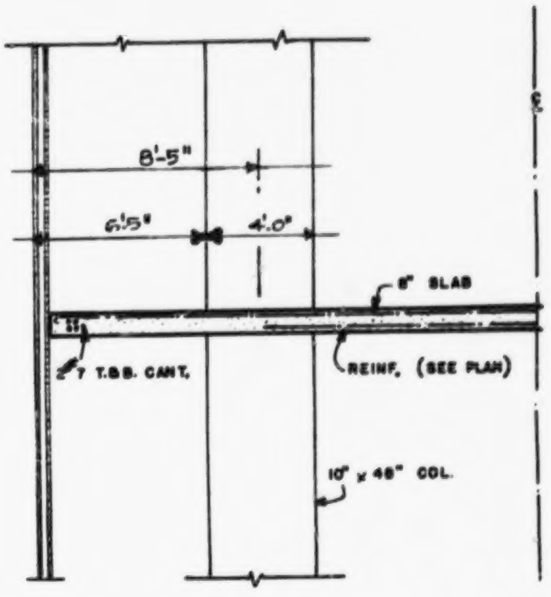
$2.50 PER SQUARE FOOT

FOUR COLUMN CAGE

CONCRETE	$ 445.00
REINFORCING	517.00
FORMS	753.00

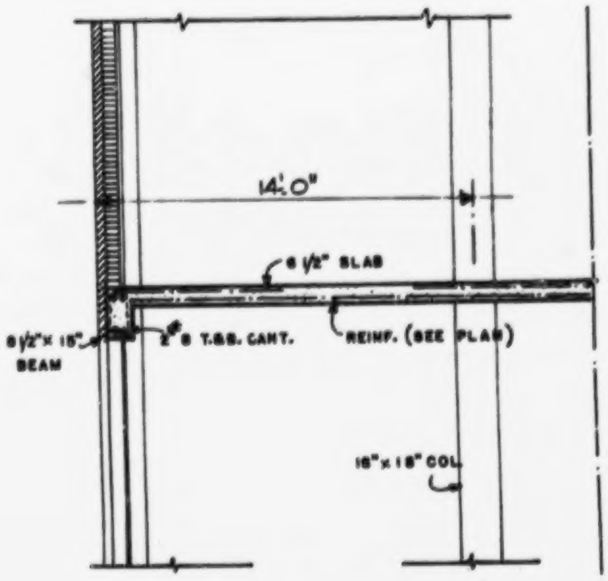
COST:
41' x 19' BAY..........$1715.00

$2.20 PER SQUARE FOOT


8'-5"
6'-5"
4'-0"
8" SLAB
2#7 T.&B. CANT.
REINF. (SEE PLAN)
10" x 48" COL.
℄

SECTION AA

$2.50 PER SQUARE FOOT (SCHEME 1)
$2.20 PER SQUARE FOOT (SCHEME 2)
SAVINGS: SCHEME 2 OVER 1 —
$.30/SQ. OR 12%.


14'-0"
8 1/2" SLAB
8 1/2"x 15" BEAM
2#8 T.&B. CANT.
REINF. (SEE PLAN)
16"x 16" COL.

SECTION BB

TWO-COLUMN CANTILEVER

2 LIFT-SLAB CONSTRUCTION

The lift-slab system has in recent years become an accepted method of erecting a structure in the safest and most economical way. It is now commonplace enough to be a standard method of erecting a building in most progressive communities in North and South America. Approval has been pending on the first lift-slab structure in New York City — a 4-slab parking garage in Mid-Manhattan. Lift-slab is a patented system of construction which relies on underbidding poured-in-place concrete construction for its existence. It is based on two premises which should form the basis of any effort by the New York State Division of Housing to reduce construction costs in public housing. This effort to combat continually rising costs of both labor and material should direct itself towards:

Search for a lighter structure:

A lighter structure will mean smaller foundations — fewer piles — fewer foundation problems where there are already too many.

Strive for greater mechanization:

Every effort should be made to take full advantage of machine techniques to supplement hand labor.

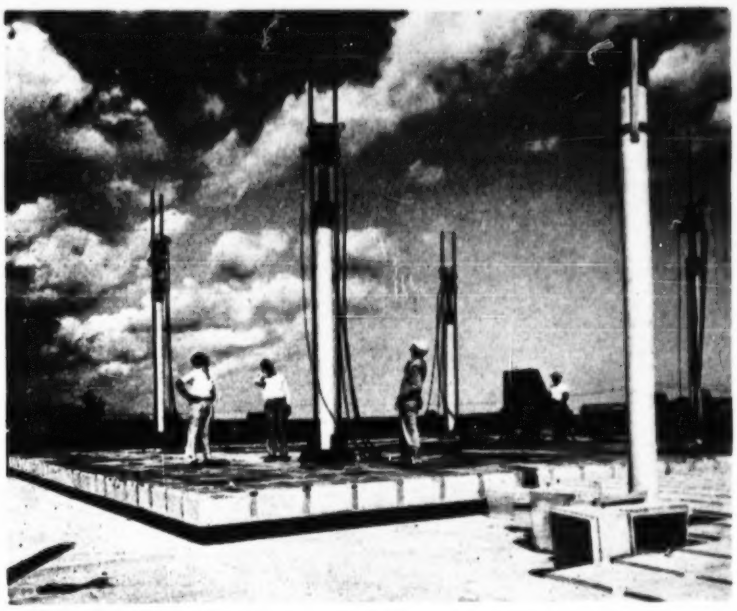
In lift-slab we have a system that achieves both and within five years will do it for less than the present cost of poured-in-place reinforced concrete frame in New York City.

With this brief introduction, we present on the following pages:

1. A review of current lift-slab construction as outlined in various engineering and architectural journals.
2. A discussion of lift-slab methods as applicable to public housing work.
3. A complete cost analysis of three public housing structures: first an example from a standard housing project now under construction (a "Y-shape" building); the other two examples from structures proposed under "Plan Studies" of this report (a "Tower Scheme" and an "Exterior Corridor Scheme"); all designed for and estimated in lift-slab construction.
4. A summation of lift-slab construction.

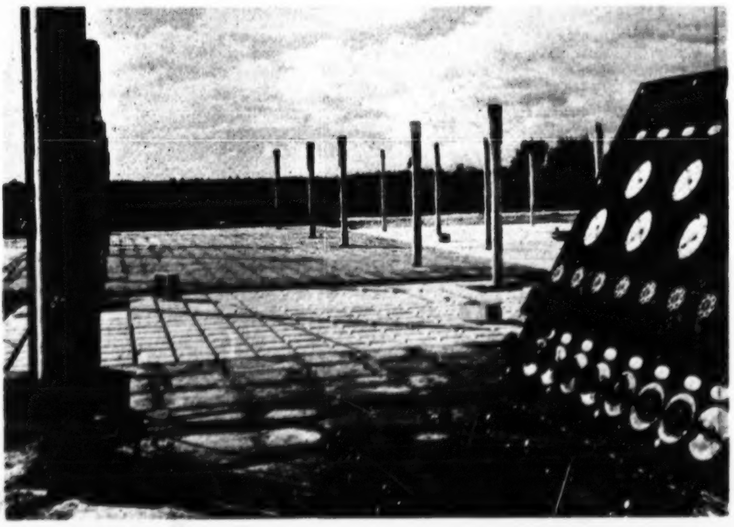
The lift-slab method is very simple:

Slabs are poured on grade one on top of another, around lifting collars surrounding permanent columns.



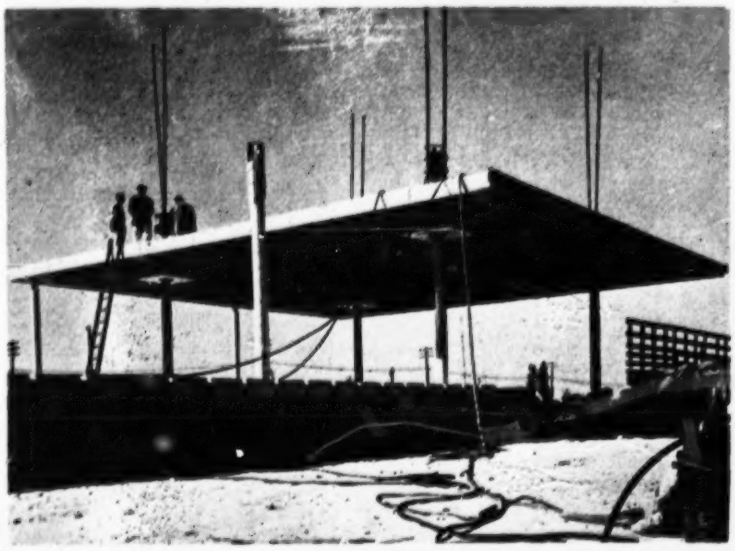
1 2

Slabs are then lifted into place to proper heights by hydraulic lifting apparatus.



3 4

Once in place slabs are permanently anchored by securing collars to supporting columns.



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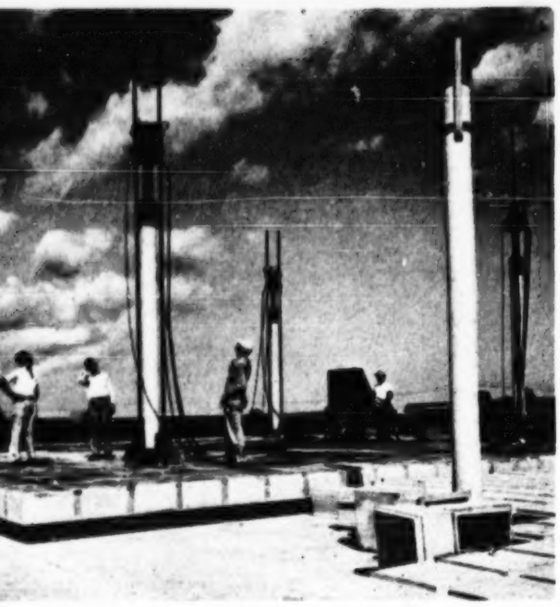
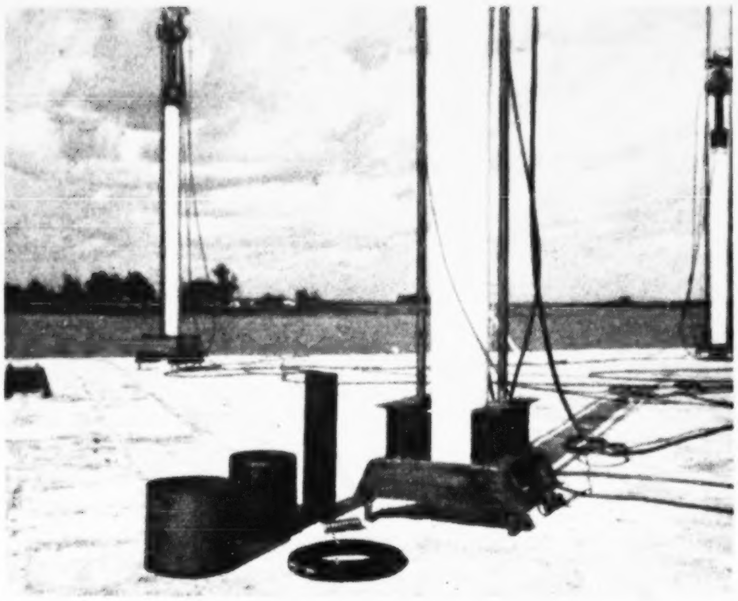
photos 1 to 6: Architectural Record March, 1952; pgs. 208-213





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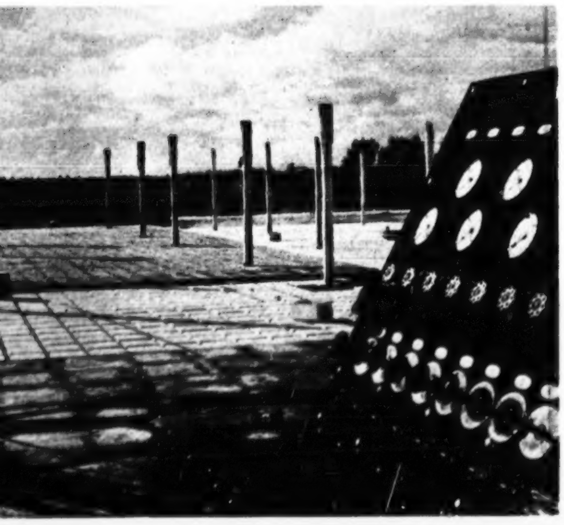

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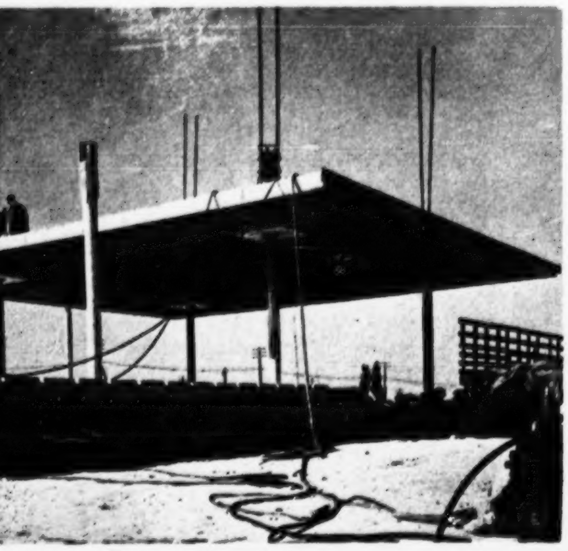

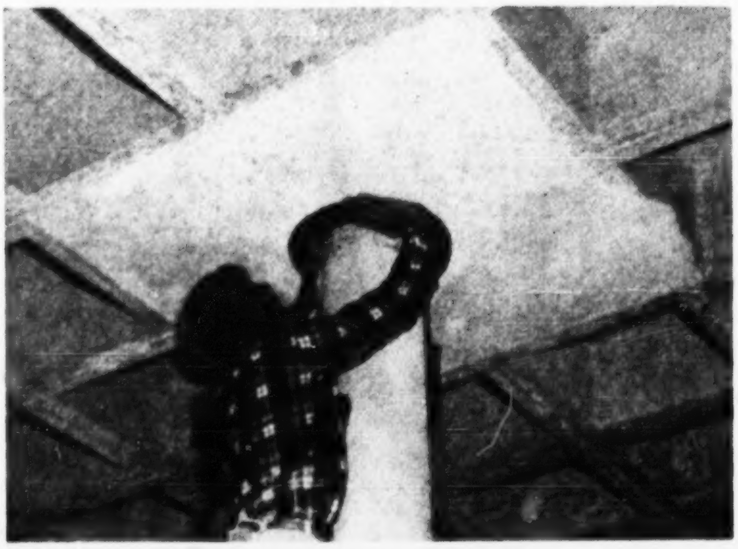

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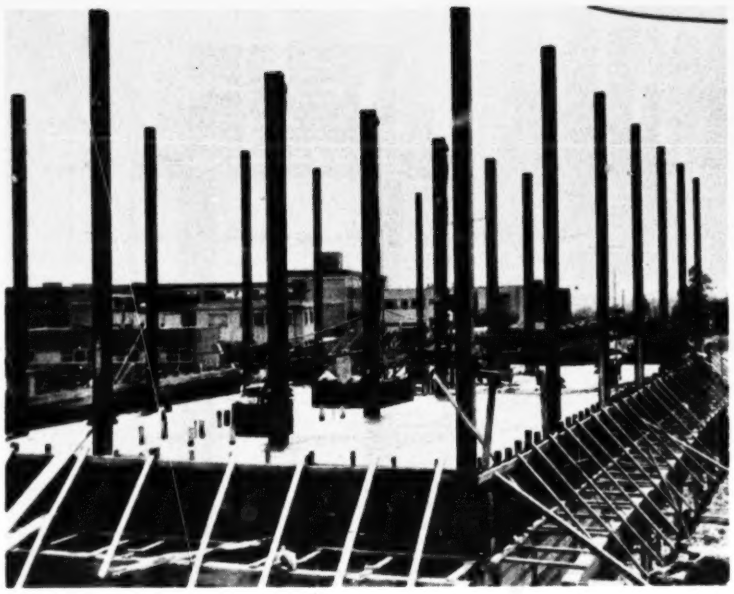
photos 1 to 6: Architectural Record March, 1952; pgs. 208-213



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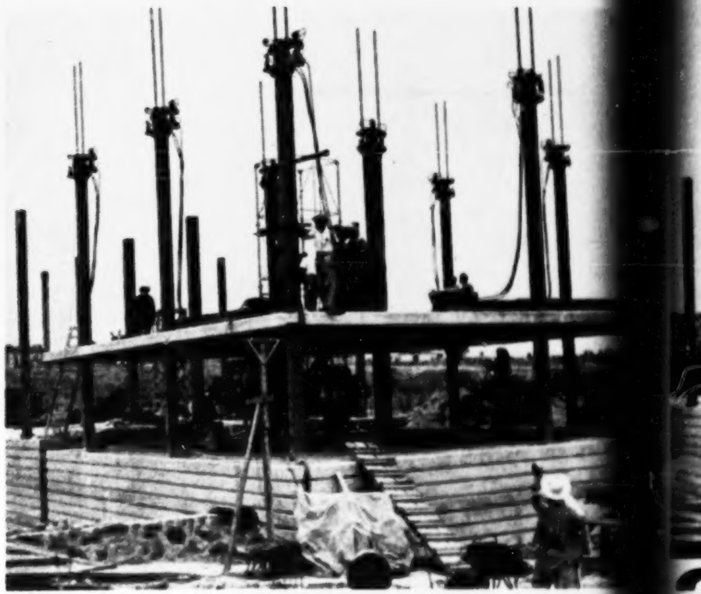

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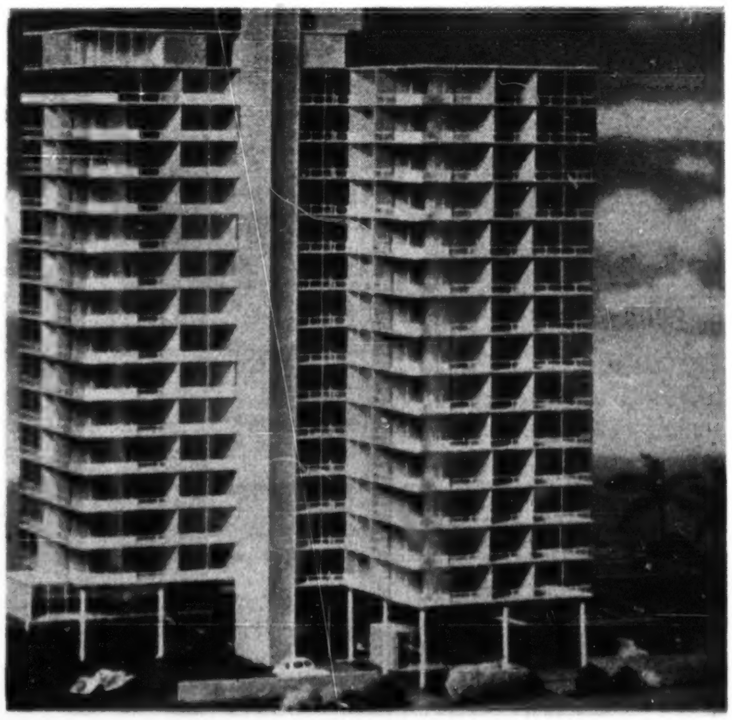

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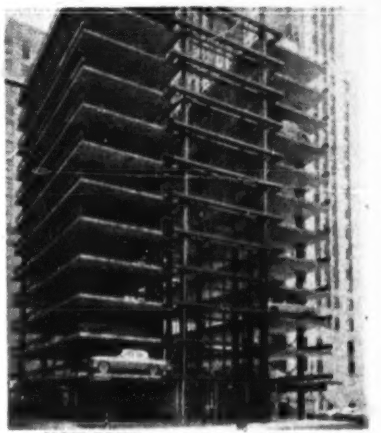
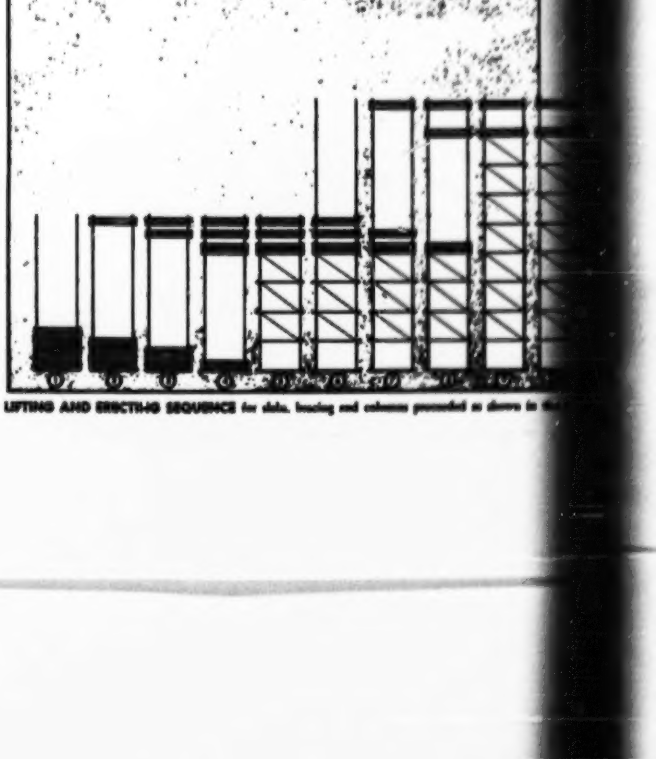


MOST DECKS ever raised in a building comprise the roof and 12 floors of a garage in Columbus, Ohio.

NEWLY CAST SLABS, 8 in. the basement floor. Top three had



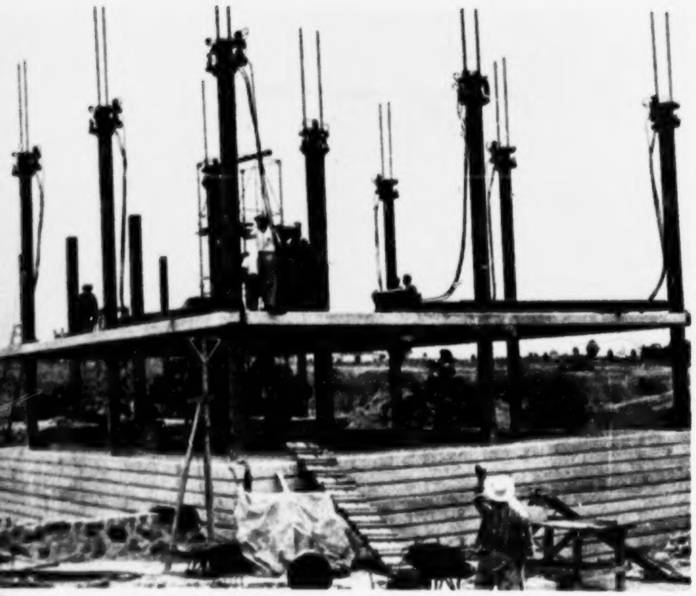
LIFTING AND ERECTING SEQUENCE for slabs, bracing and columns proceeded as shown in the

Review of Lift-Slab Construction

Engr.-News Record, 26 Dec., 1957

"Lift-Slab Record Breaker Planned"

"A Florida firm plans to start construction next month on the world's tallest lift-slab building, a 14-story $1½ million cooperative apartment house in Hallandale."



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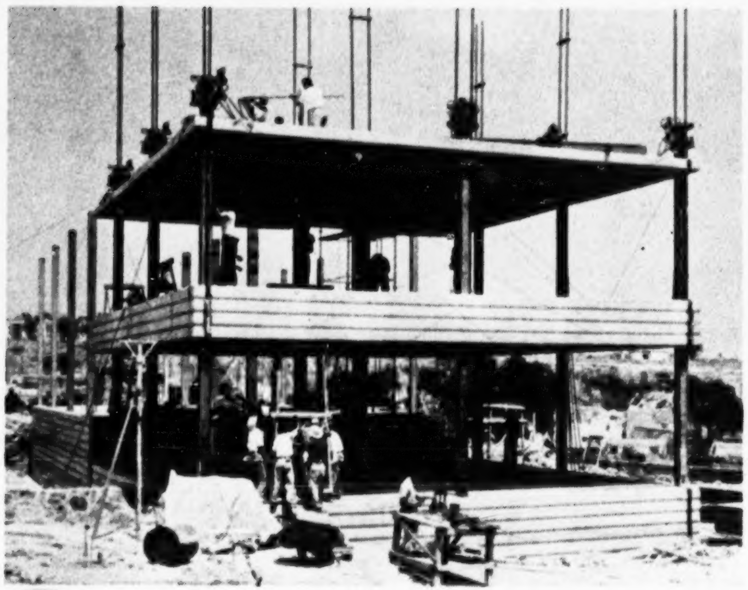

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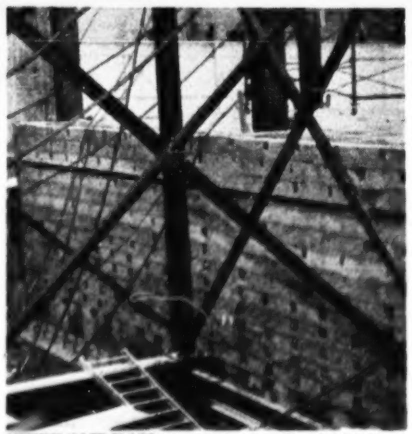
…OST DECKS ever raised in a building comprise the …d and 12 floors of a garage in Columbus, Ohio.



NEWLY CAST SLABS, 8 in. thick, make a stack nearly 9 ft high on the basement floor. Top three had started up when photo was snapped.

Lifting speeds ranged up to 12 ft per hour.

UPPER SLABS were parked at the top of the columns pending the lifting, fastening and bracing of slabs below, and erection of the next tier of columns.

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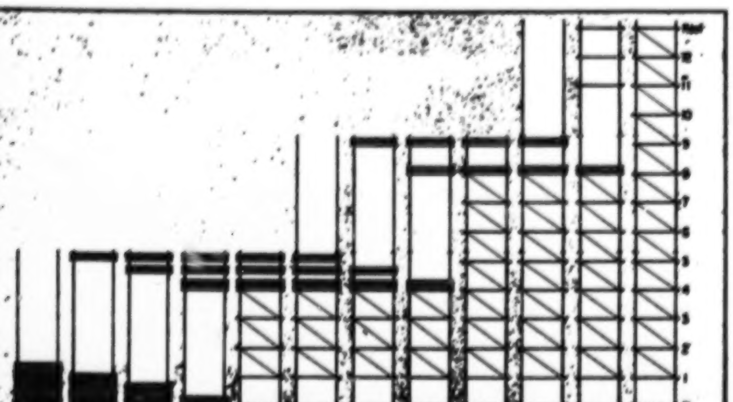
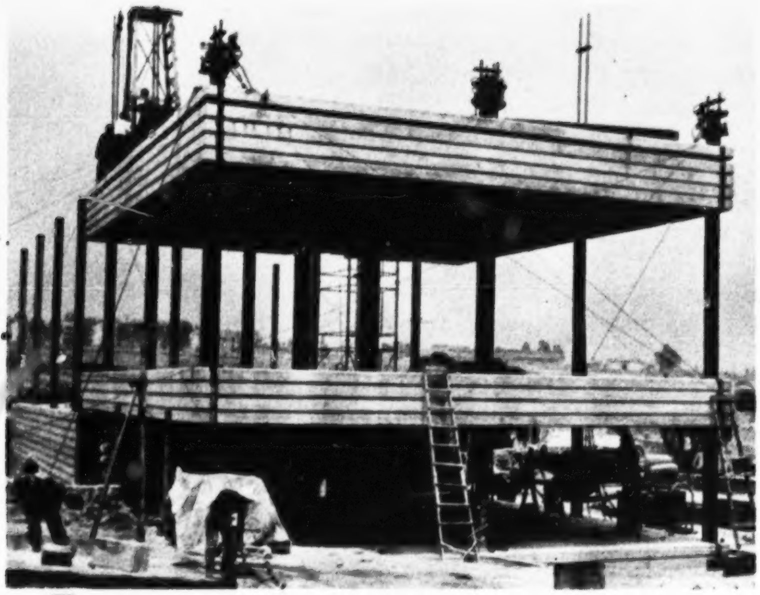


…TING AND ERECTING SEQUENCE for slabs, bracing and columns proceeded as shown in the step-by-step diagrams above.

Engr.-News Record, 3 July, 1958

"Height Record Goes Up Again for Lift-Slabs in the U.S."

Erection of the Tower Parking Garage in Columbus, Ohio, has jacked up the U.S. height record for lift-slabs another notch. The structure rises 88 ft. above street level. That's 11 ft. more than the Citizens Security Corp.'s two-year-old parking garage in Cincinnati, which formerly ranked as the country's tallest lift-slab building (ENR May 6, 1956, p. 25). Counting the basement and roof, the new garage has 14 parking levels. All but the basement were raised as lift-slabs from a stacked position on the basement floor, where they were cast.



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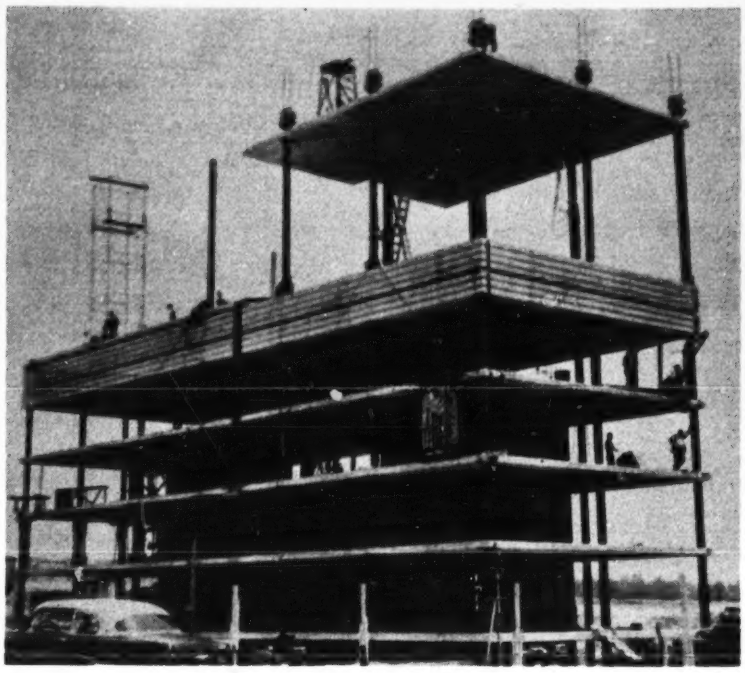

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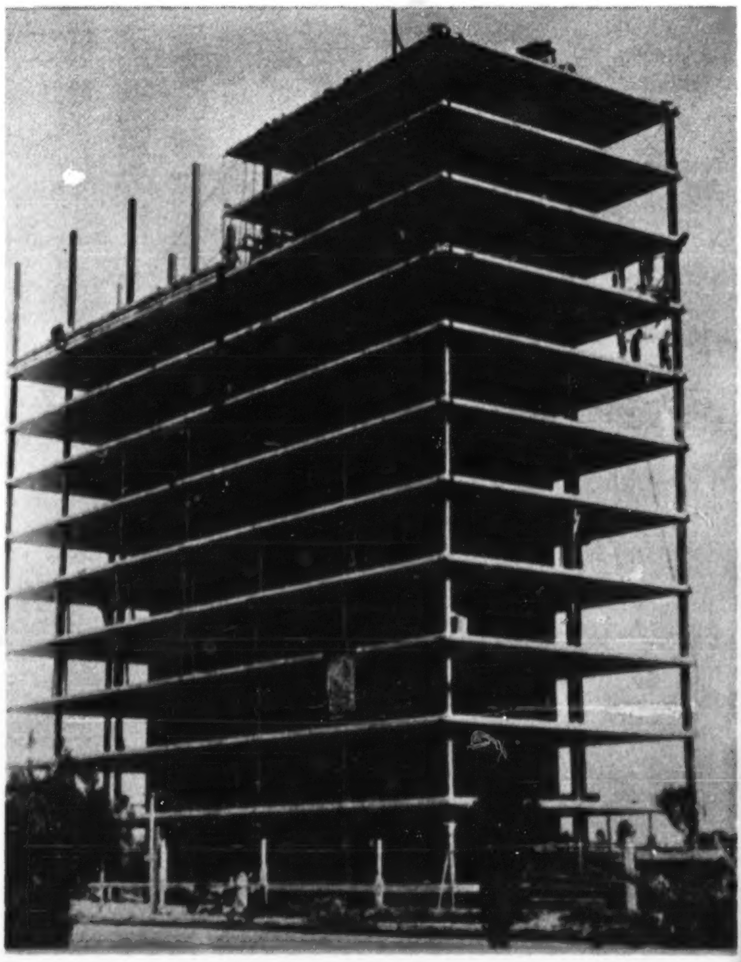
photos 1 to 6: courtesy of Lift Slab Corp., New York



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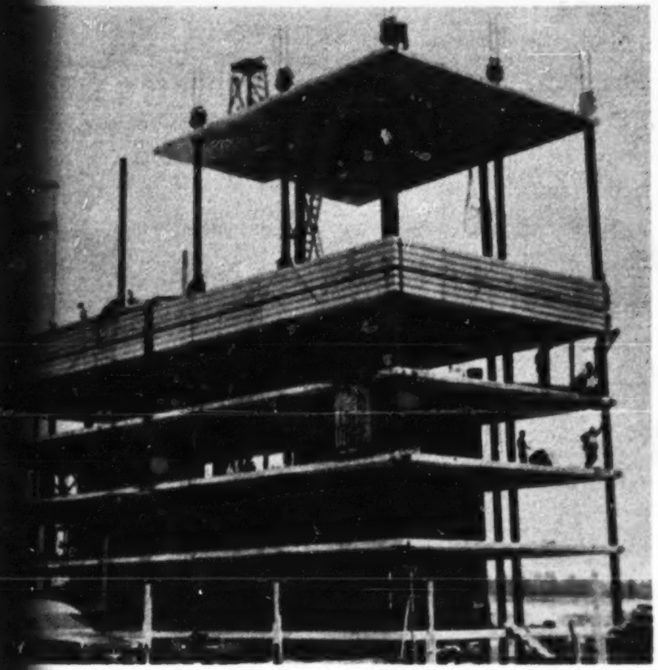
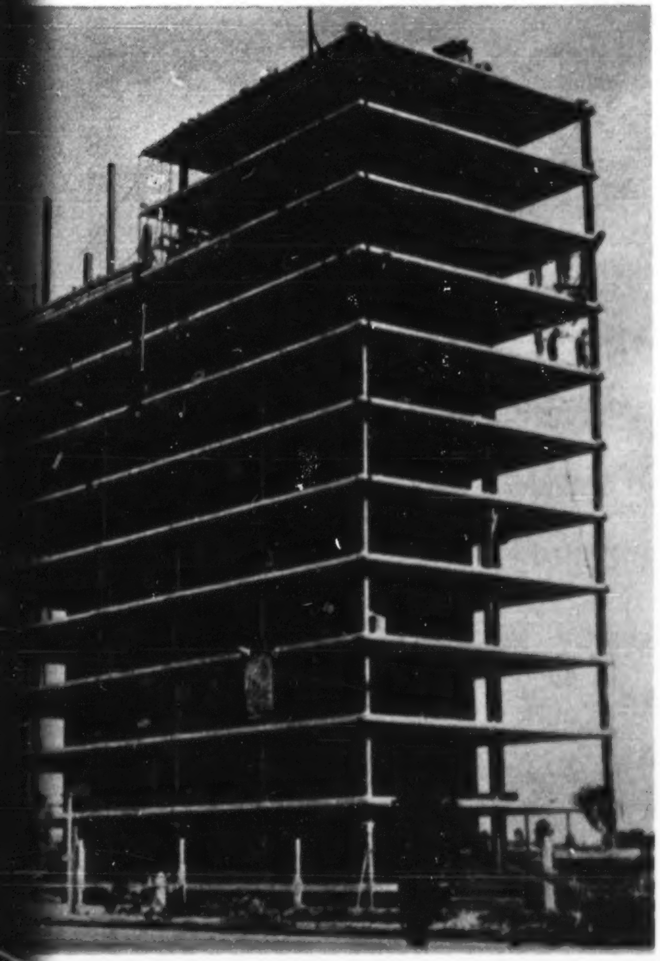


Engr.-News Record, 7 Nov., 1957

"With erection of a 101 ft. high apartment house... Mexican Builders Set Lift-Slab Mark"

"The tallest concrete lift-slab building ever constructed is nearing completion in Mexico City. It is an 11 story-and-basement, 101 ft. high apartment house."

"The structure is part of a $5 million luxury co-operative apartment house project being built by Centros Urbanos, S. A., a private Mexican firm. Companion buildings are four 10-story apartment houses (also lift-slab type) and a commercial center."



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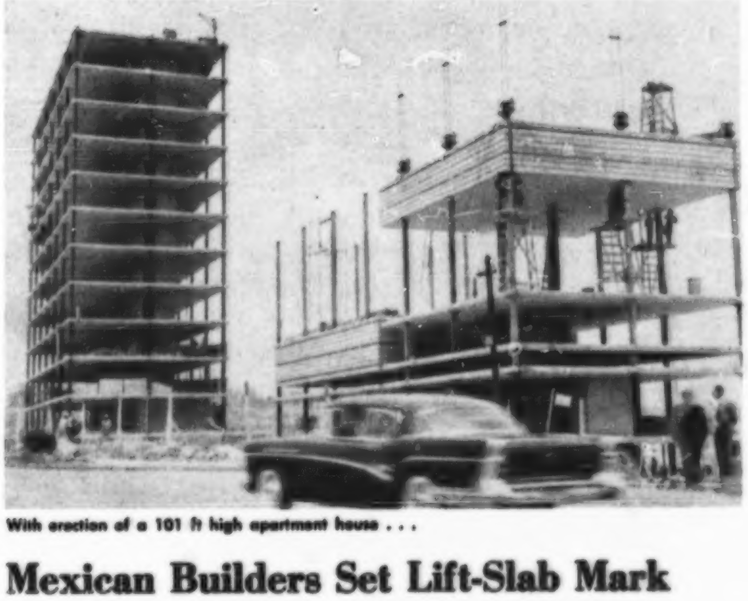

With erection of a 101 ft high apartment house . . .

Mexican Builders Set Lift-Slab Mark

Lift-Slab Methods In Public Housing Work

In public housing work the use of lift-slab construction has two basic requirements: The entire project must be carefully designed from early sketch stages with lift-slab in mind, and then the project must be engineered for lifting.

Designing:

No building should be "redesigned" for erection by lift slab. Such a building will not be able to take full advantage of the particular characteristics of this building system and will therefore be a costly structure. Lift slab works best with a regular column spacing, with columns "in-line" on a grid system rather than "spattered" as in standard public housing construction. Bays should have a 2-to-3 ratio in size with 20′ to 25′ as maximum dimension — say 16′x24′. All this requires careful layout of apartments (horizontally as well as vertically). Columns should not be "off-set" too much but 2′-0″ to 2′-6″ off center is still economically possible. Avoid large openings (other than stairs and elevators) in the slabs — rather, use more scattered sleeves in slabs. Balconies, exterior corridors, etc., can easily be lifted as part of the main slab. Remembering that a lifted slab requires no spandrel beams, openings in exterior walls can go from slab to slab. Use minimum floor heights — 8′-1″ is recommended; with 7″ slab this gives 7′-6″ clear room height suggested by many designers for public housing work. (See further discussion of this subject in Chapter Four.) Building wings should have 6000 to 12000 sq. ft. per lift. Most of these basic rules will help produce a very economical lift-slab structure. As they are disregarded, the final cost goes up. These requirements will not necessarily confine apartment layouts to rigid patterns nor do they require any substantial revision to present New York State Division of Housing design standards. Two of the schemes discussed in "Plan Studies" section of this report have been designed to meet most of these requirements and both have complied with New York State Division of Housing room and apartment layout standards while proving to be well suited to lift-slab procedure.

Engineering:

Structural engineering of lift-slab is a major part of the design for a structure to be erected in this manner. As many engineers who have worked with this system have found, the analysis and design is identical in many respects to any other structural analysis and design. Two items do differ in this system, and they are the column design and the collar design.

Column Design:

As the first slab is lifted by hydraulic jacks, the column has no restraint at the top and is fixed or built-in at the bottom. Jack is centered on column at top — this column has a concentric load equal to dead load reaction of slab (or slabs) being lifted. It has been found that Euler's equation with an appropriate factor of safety (due mostly to impact at start of lifting) can be used:

$$P=\frac{\pi^2 E\,I}{L^2}$$

where: P = critical load value
E = modulus of elasticity
I = moment of inertia of the column section
L = free length of column

With column built in at bottom and free at top:
$L = 2 \times l$
where: l = free length of column

Thus, the above equation for bottom-fixed columns reduces to:

$$P=\frac{\pi^2 E\,I}{(2l)^2}\quad P=\frac{\pi^2 E\,I}{4(l)^2}$$

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Thus, the above equation for bottom-fixed columns reduces to:

$$P = \frac{\pi^2 E I}{(2l)^2} \quad P = \frac{\pi^2 E I}{4(l)^2}$$

Once slabs are secured in place columns can be checked by any equation recommended by building codes for axially loaded columns:

$$P/A \; 17000 - .485 \frac{l^2}{r^2}$$

For columns where l/r less than 120

where: P/A = allowable axial stress
l = free length of columns
r = radius of gyration

In general, steel columns can be pipe, H-sections, or squares formed of angles; precast concrete columns may be round or square. For economical collar shapes, it is desirable to use column sections that are symmetrical about both axes.

Collar design:

The lifting collar, usually a cast steel plate, serves three purposes. Placed around the column, it is cast into the concrete slab when it is poured. Rods are fastened through this collar which in turn lifts the slab as the threaded rods are turned. Once up collars are locked to columns, supporting slabs. Finally, the collar becomes a stiffening capital for the column. Collar being stronger will not deflect like the slab. Its size and detail are based on two conditions: shear from the slab reaction — for this (with no deflection of collar) the following equation can be used:

$$v = \frac{V}{b j d}$$

where: V = reaction due to total load
b = periphery around collar (width of collar plus twice effective depth of slab around entire collar or, 4 (b-2d)).
j = assumed as .875
d = distance from center of gravity of tensile reinforcing to compression face of the slab.

Bearing stress between collar and concrete slab must be within specified limits.

Following is a brief outline of the complete design procedure for a multi-story lift slab structure:

1 Lay out floor plans, locating columns in a rectangular grid. Column spacing is the most important engineering feature to provide the most economical design. Use of cantilevers, if feasible, greatly increases effective use of reinforcing steel in slabs, thereby resulting in added economy.

2 Lift-slabs should be designed according to American Concrete Institute Building Code as a flat slab panel. This method permits each row of columns to be analyzed as a bent and apportions calculated reinforcing steel into column and middle strips. Analysis used for design of each bent is a moment distribution system with bent considered a continuous frame. One method used is a modification of analogy by Professor Hardy Cross and can be found in any standard reference book.

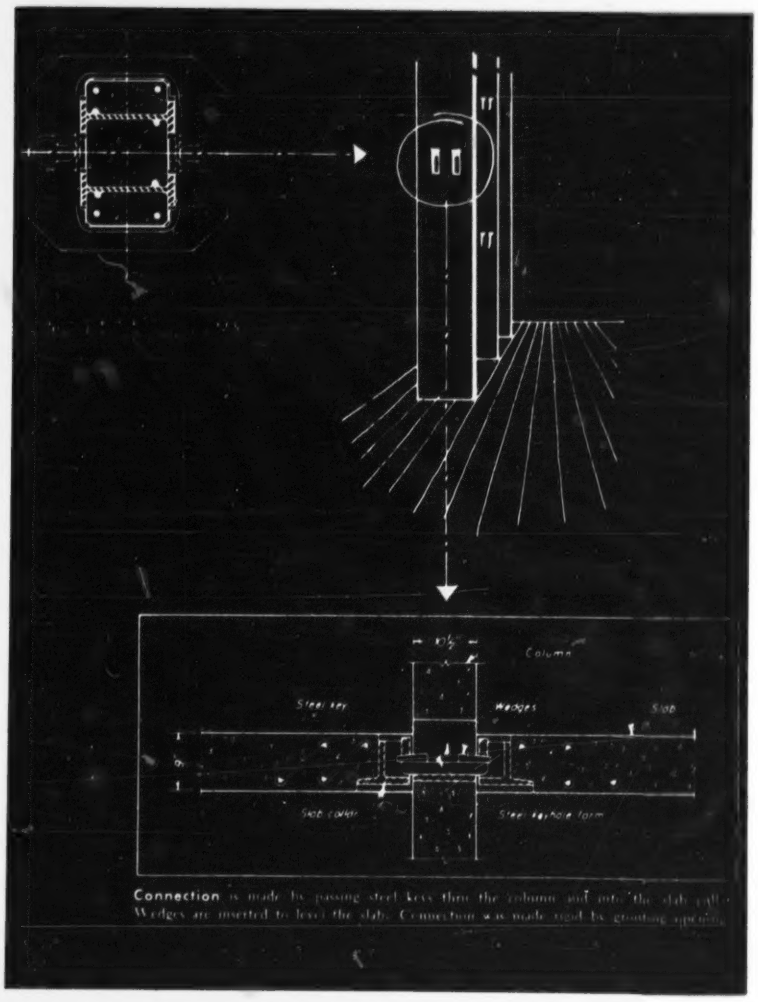
3 Design of columns previously discussed. Two major conditions for consideration of each column are (1) a fixed column in static load application, to include both dead and superimposed loads, and (2) a column used as a lifting support and acting as a vertical cantilevered beam. In both cases, column is axially loaded and should be designed that way. It is apparent that column is critical in cantilevered position, since slenderness ratio is very high compared to static condition.

4 Design of collar connector previously discussed. Connector is designed as a direct shear connector, and collar plate must be considered as a flat plate not subject to deflection. Assumption becomes reasonable due to collar's size and section. Several tests have been performed with collars to show that no deflection is present. Collar plate extends into slab and becomes a fixed column-head or capital as well as an integral part of slab. Column must take any lateral loads after building erection, it is also necessary to provide a moment connection between collar and column.

5 Design of footings. In designing an isolated footing for a column, consider column and footing as a cantilevered retaining wall. If column is to be used for partial support in wind bracing, imposed wind loads must be added.

6 Remembering that lift-slabs are not static during lifting operations, they will therefore be in a deflected position the instant they become free of slab upon which they were poured. After slab is fastened in position, deflection will take a final set which is somewhat less than deflection during lifting. In a lifting position, slab is exactly as assumed in analogy of a beam or column by moment distribution.

The structural columns can be either concrete (reinforced), with various methods of securing slabs to columns:



Connection is made by passing steel keys thru the column and into the slab coll
Wedges are inserted to level the slab. Connection was made rigid by grouting openin

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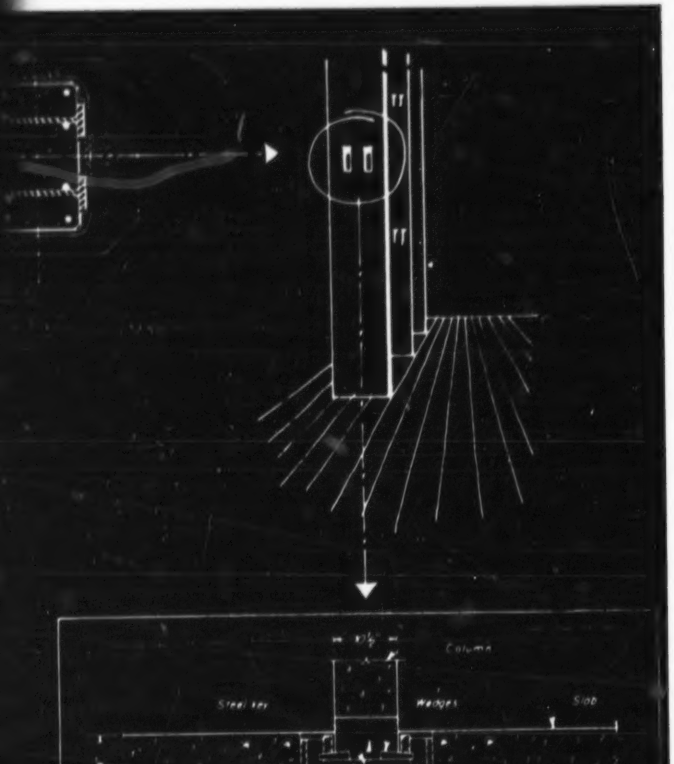
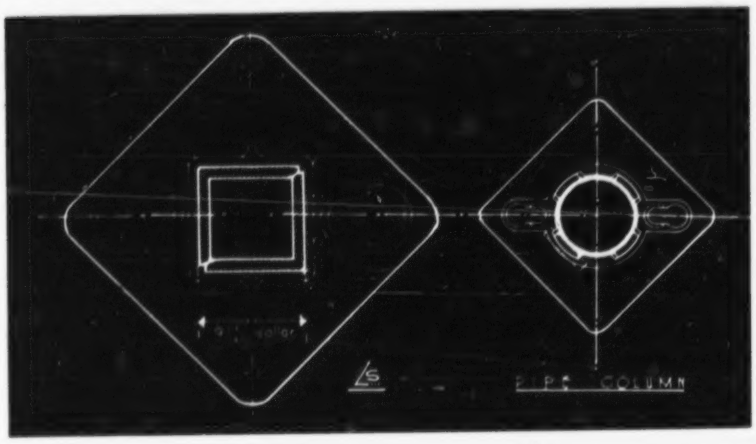
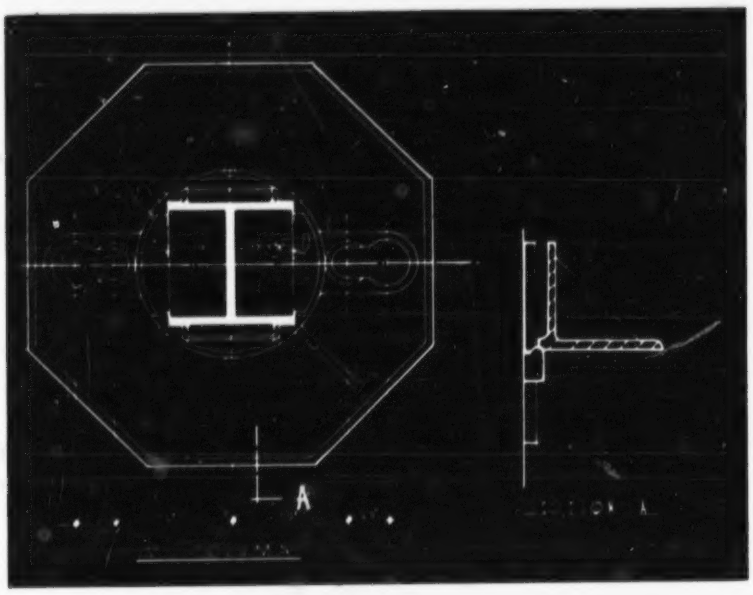


Connection is made by passing steel keys thru the column and into the slab colla Wedges are inserted to level the slabs. Connection was made rigid by grouting opening

or steel angles or sections, with concrete poured into hollow sections after slabs are secured:



or steel H-sections, with fire proofing sprayed on after slab collars are welded in place:



The slabs can be flat plate with finished floor and ceiling faces applied prior to lifting:

or "waffle-type" lightweight slabs, accepting waffled ceiling pattern for its acoustical properties.

Cost Analysis of Three Housing Projects

This section will investigate the cost of lifting three different public housing projects and compare all three to current costs of a similar structure of reinforced concrete.

First, it would be well to review just where the economies lie in the lift-slab method. Then we can proceed to the complete cost comparison of the three structures.

There are at least six main areas in construction work where lifting a slab proves to be more economical than pouring it in place. It must be remembered that these are current economies — more will accrue in the near future as this method of construction becomes more familiar. The six main areas are: forms, concrete, reinforcing steel, structural steel, imbedded items, and overhead.

In lift-slab, the only forms required are edge forms around slab, while a formed-in-place slab requires edge forms, soffit panels, joists, beams, shores, bracing, and in many cases, form clamps. Time and labor are also required in laying out, plumbing, centering forms. After slabs are cured, forms must be stripped and cleaned before another use. Definite savings in material and labor as well as time, are obvious.

Concrete poured for lift-slab is handled on the ground and can in many cases be "shot" directly from truck. If paver is used, boom can be placed over or close to spot where concrete goes. Working, placing, and finishing is all done at ground level and results in better efficiency by workmen and easier handling of tools and finishing materials. If slab is formed in place, concrete must be hoisted up to forms and a portion of it buggied. Workmen are not as efficient at higher elevation: all tools and materials have to be hoisted. Time as well as costs are saved by lift-slab method in this function.

Reinforcing steel is all placed and tied at ground level in lift-slab construction. This means no hoisting of bars, chairs, and other slab accessories.

Structural steel is placed and set when columns are put on the piers. Cast steel collars are hung on columns just before erection, thereby eliminating need for scaffolds or winch lines. Columns do not have to be wedged or realigned at each floor as would be necessary if slabs were poured in place.

Imbedded items that go into any slab are placed in lift-slab at ground level. Sleeves, conduits, thimbles, chases, hanger sockets, all openings are laid out and prepared on ground slab. Partition walls may be marked out with chalk line or grease crayon and, after slabs lifted, marks will appear on ceiling as well as on floor. This means much less complication in layout of entire building. Sleeves and conduits are placed in slabs and tied to reinforcing steel. In multi-storied construction, sleeves will therefore be in perfect alignment throughout height of structure.

Savings in above items will mean savings in time which will be reflected in reduction of actual labor costs as well as overhead costs. Need for templates to make forms is eliminated, as is need for power saws and special form tools. Necessary clean-up of job is at a bare minimum. By storing materials under lifted slabs, fewer storage shacks are necessary. In doing a job in less time with few men, supervision is at minimum in both personnel and time on job. Time also affects the insurance premiums through the construction period. A reduction of construction time can cut both contractor's and New York State Division of Housing's overhead per project.

Masonry and other materials for multi-storied building can be placed on slabs before lifting, saving time and money in hoisting. Lift slabs also give masons a complete building one section after another in a definite pattern. Slabs in place give weather protection which enables masons and other trades to work in rain. Heating systems can be assembled on each floor einforcing steel is all placed and tied at ground evel in lift-slab construction. This means no hoisting f bars, chairs, and other slab accessories.

tructural steel is placed and set when columns are ut on the piers. Cast steel collars are hung on col- mns just before erection, thereby eliminating need or scaffolds or winch lines. Columns do not have to e wedged or realigned at each floor as would be ecessary if slabs were poured in place.

mbedded items that go into any slab are placed in ift-slab at ground level. Sleeves, conduits, thimbles, hases, hanger sockets, all openings are laid out and repared on ground slab. Partition walls may be narked out with chalk line or grease crayon and, fter slabs lifted, marks will appear on ceiling as well s on floor. This means much less complication in ayout of entire building. Sleeves and conduits are laced in slabs and tied to reinforcing steel. In multi- toried construction, sleeves will therefore be in per- ect alignment throughout height of structure.

Savings in above items will mean savings in time which vill be reflected in reduction of actual labor costs as vell as overhead costs. Need for templates to make orms is eliminated, as is need for power saws and pecial form tools. Necessary clean-up of job is at a bare minimum. By storing materials under lifted slabs, fewer storage shacks are necessary. In doing a job in less time with few men, supervision is at minimum in both personnel and time on job. Time also affects the insurance premiums through the construction period. A reduction of construction time can cut both con- ractor's and New York State Division of Housing's overhead per project.

Masonry and other materials for multi-storied building can be placed on slabs before lifting, saving time and money in hoisting. Lift slabs also give masons a complete building one section after another in a definite pattern. Slabs in place give weather protection which enables masons and other trades to work in rain. Heating systems can be assembled on each floor slab and pulled straight up into place, without having to go under or into beams or joists. Many electrical conduits and mechanical runs can be prefabricated and set into place on ground. Complete plumbing manifolds and stacks can be made up, placed on slabs and hoisted with slabs. Access to section of building where plumbing goes is good because there are no obstructions such as shores or forms.

With this list of where some of the economies are in lift-slab work, let us examine the cost estimates for three projects:

Building "A"—"Y-Shape" Building

Building "B"—"Slab-Type" Building

Building "C"—"Tower-Type" Building

The complete design analysis (from drawings and data furnished by research group) and cost estimate was completed with the cooperation of the Lift-Slab Corp. of New York City, under the supervision of Mr. Robert Egelhoff.

Final results, general design layouts, engineering data and costs checked during various interviews with:

Mr. Seymour Gage
Gage & Martinson, Engrs., N.Y.C.

Mr. Marenberg
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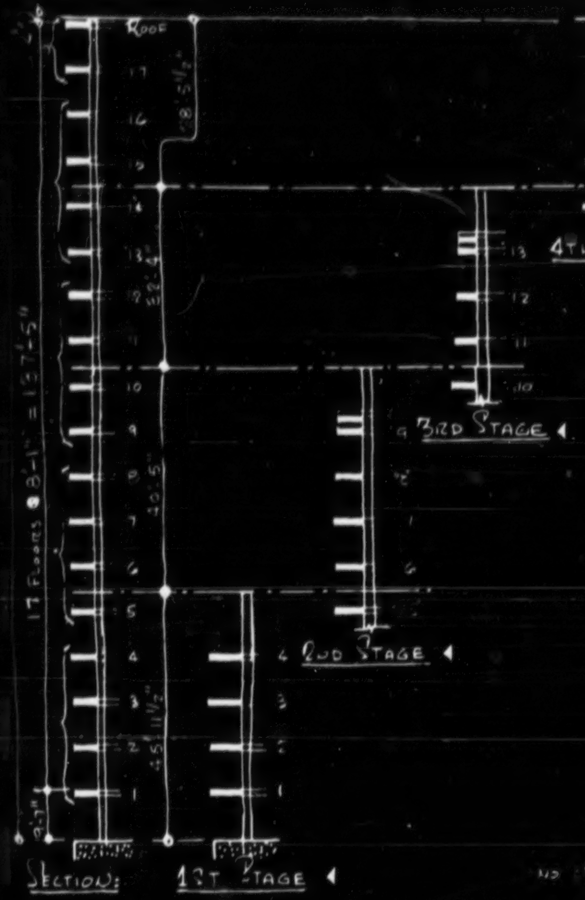
Severud, Elstad & Krueger, Engrs.
415 Lexington Avenue, N.Y.C.



A
BUILDING A: Y SCHEME

2-21 Col. Sections } Wing (A)
2-16 Col. Sections }

1-22 Col. Section } Wing (C)

No. of Lifted Slabs: 18 ←

Roof Load:

6½" LW Conc. Slab @ 112#/ft³	= 61.0
Roofing & Insulation	= 10.0
L	= 40.0
	111.0#/□

Lifted Area:

Wings "C" = 2(54.2)(39.5)(18) = … 619
Wing "A" = (143.58)(39.29)(18) = …
185,9… 1

Say 185,000 Sq. Ft. - (A)

Typ. Floor Load:

6½" LW Conc. Slab	= 61.0
Partitions	= 20.0
LL	= 40.0
	121.0#/□

Max. Span = 20'-5½"
$l/36$ = 20.46(12)/36 = 6.83"
→ {Base Est. on 6½" Slab But Final Design Might Have To Be 7"}

LL Reduction Not Figured In Estimated Col. Sizes As Final Design Wind Condition Will Closely Compensate For This:

A
BUILDING A: Y SCHEME

Wing "C" - Max. Exterior Reactions:

Roof:	15.75(10.54)(111)	= 18,400
7	15.75(10.54)(121)	= 20,100 + 5,700 {Wall
6	"	25,300
5	"	25,300
4	"	25,300
3	"	26,300
2	"	25,300
1	"	25,300
0	"	25,300
9	"	25,300
8	"	25,300
7	"	25,300
6	"	26,300
5	"	25,300
4	"	25,300
3	"	25,300
2	"	25,300
1	"	25,300
		448,500#

Av. Total Col. Wt. = 147(85) = 12,500#
461,000# Total

Wing "C" - Max. Interior Reactions:

Roof:	18.42(15.75)(111)	= 32,200
17	18.42(15.75)(121)	= 35,100
16	"	35,100
15	"	35,100
14	"	35,100
13	"	35,100
12	"	35,100
11	"	35,100
10	"	35,100
9	"	35,100
8	"	35,100
7	"	35,100
6	"	35,100
5	"	35,100
4	"	35,100
3	"	35,100
2	"	35,100
1	"	35,100
		628,900#

Av. Total Col. Wt. = 147(95) = 14,000#
642,900# Total

Lifted DL/Slab = 15.75(10.54)(61) = 10,130#
Bottom Slab Stack = 9'-9" Thick

Lifted DL/Slab = 18.42(15.75)(61) = 17,700#

Design 1st Stage Col.:

Cant. "l" = [45'-11½"] - [8'-8"] = 37'-3½" = 447.5"
DL (Rf & 17) = 20,260#

$$I_{REQ'D} = \frac{4(447.5)^2(20,760)(1.75)}{\pi^2(29,000,000)} = 99.2\ IN^4$$

Try 12WF99

$$P_{ULT.} = \frac{\pi^2(29,000,000)(278.2)}{4(447.5)(447.5)} = 99,800\#$$

S.F. = 99,800/20,760 = 4.70 > 1.75 So O.K.
On 37' Length Good For 215k > 61k (6 Slabs)
On " " " 215k > 101.3k (10 Slabs)
On " " " 215k > 142.0k (14 Slabs)
On " " " 215k > 183.0k (18 Slabs)

12WF99 - 1st Stage Ext. **a**

Design 2nd Stage Col.:

Cant. "l" = 43'1" = 517"
12(25,300) = 304,000 + 18,400 + 8,500 = 330,900#

$$I_{REQ'D} = \frac{4(517)^2(20,760)(1.75)}{\pi^2(29,000,000)} = 132.2\ IN^4$$

Try 12WF79

$$P_{ULT.} = \frac{\pi^2(29,000,000)(216.4)}{4(517)(517)} = 55,300\#$$

S.F. = 55.3/20.76 = 2.73 > 1.75 So O.K.
On 40' Length Is Good For 143k > 61k (6 Slabs)
On " " " 143k > 101.3k (10 Slabs)
On " " " 143k > 142k (14 Slabs)

12WF79 - 2nd Stage Ext. **c**

Design 3rd Stage - Exterior:

Cant. "l" = 34'2" = 410"
7(25,300) + 18,400 + 5,000 = 200,400#

$$I_{REQ'D} = \frac{4(410)^2(20,760)(1.75)}{\pi^2(29,000,000)} = 83.3\ IN^4$$

Try 12WF53

$$P_{ULT.} = \frac{\pi^2(29,000,000)(96.1)}{4(410)(410)} = 41,000\#$$

S.F. = 41,000/20,760 = 2.02 > 1.75 So O.K.
On 32' Length Good For 99k > 61k (6 Slabs)
On " " " 99k > 91.2k (9 Slabs)

12WF53 - 3rd Stage Ext. **e**

Design 4th Stage - Exterior:

Cant. "l" = 30'-6" = 366"
3(25,300) + 18,400 + 2,600 = 97,000#

$$I_{REQ'D} = \frac{4(366)^2(20,760)(1.75)}{\pi^2(29,000,000)} = 66.7\ IN^4$$

Try 12WF53:

$$P_{ULT.} = \frac{\pi^2(29,000,000)(96.1)}{4(366)(366)} = 51,300\#$$

S.F. = 51,300/20,760 = 2.53 > 1.75 So O.K.
On 37' Length Good For 99k > 51k (5 Slabs)

12WF53 - 4th Stage Ext. **g**

Lower Length Exterior - Total Load:

P = 461,000#
12WF99 On 9' Length Good For 477k > 461k

12WF99 - O.K. Total Load **i**

Column Base PL Design - Exterior:

P = 461,000#
461,000/600 = 770 □" ← Try 28" × 28" PL
n = 14.0 - (.40 × 6) = 11.6"
t = 11.6(.3) = 3.5"

Use 28 × 3½ × 28 Base PL **k**

Ext. Col. Weight - Estimated:

12WF99 × 47' Long	= 4,650#
12WF79 × 40.42' "	= 3,190#
12WF53 × 38.33' "	= 1,660#
12WF53 × 28.46' "	= 1,510#
28 × 3¼ × 28 Base PL	= 778#
	11,788#/Col.

44 Ext. Cols. @ 11,788# Ea. = 518,672#

Weld Blocks (2/Conn.)

Without Figuring Wind Load
Assume 2 - 4×4×5/8 Weld Block
36(74 Cols.) @ 3# Ea. = 8,000#

Total Weld Blocks (Int. & Ext.) →

Design 1st Stage Col.:

Cant. "l" = 447.5"
DL (7 Slabs) = 35,400#

Try 12WF161

$$P_{ULT.} = \frac{\pi^2(29,000,000)(486.2)}{4(447.5)(447.5)} = 173,500\#$$

S.F. = 173,500/35,400 = 4.90 > 1.75 So O.K.
On 37' Length Good For 374k > 106k (6 Slab
On " " " 374k > 177k (10 Slab
On " " " 374k > 248k (14 Slab
On " " " 374k > 320k (18 Slab

12WF161 - 1st Stage Int. **b**

Design 2nd Stage Col.:

Cant. "l" = 517"
12(35,100) = 422,000 + 37,700 + 9,500 = 465,70

$$I_{REQ'D} = \frac{4(517)^2(35,400)(1.75)}{\pi^2(29,000,000)} = 230\ IN^4$$

Try 12WF133:

$$P_{ULT.} = \frac{\pi^2(29,000,000)(389.9)}{4(517)(517)} = 104,000\#$$

S.F. = 104,000/35,400 = 2.94 > 1.75 So O.K.
On 40' Length Is Good For 260k > 106k (6 Slab
On " " " 260k > 177k (10 Slab
On " " " 260k > 248k (14 Slab

12WF133 - 2nd Stage Int.

Design 3rd Stage - Interior:

Cant. "l" = 410"
7(35,100) = 246,000 + 37,700 + 5,800 = 284,00

$$I_{REQ'D} = \frac{4(410)^2(35,400)(1.75)}{\pi^2(29,000,000)} = 146\ IN^4$$

Try 12WF65:

$$P_{ULT.} = \frac{\pi^2(29,000,000)(174.6)}{4(410)(410)} = 74,000\#$$

S.F. = 74,000/35,400 = 2.09 > 1.75 So O.K.
On 32' Length Good For 175k > 106k (6 Sl
On " " " 175k > 160k (9 Sl

12WF65 - 3rd Stage Ext.

Design 4th Stage - Interior:

Cant. "l" = 366"
3(35,100) + 37,700 + 3,000 = 140,700#

$$I_{REQ'D} = \frac{4(366)^2(35,400)(1.75)}{\pi^2(29,000,000)} = 116\ IN^4$$

Try 12WF58:

$$P_{ULT.} = \frac{\pi^2(29,000,000)(107.4)}{4(366)(366)} = 57,500\#$$

S.F. = 57,500/35,400 = 1.63 < 1.75 But O.K.
On 37' Length Good For 99k > 89k (5 Sla

12WF58 - 4th Stage Ext.

Lower Length Interior - Total Load:

P = 650,000#
12WF161 On 9' Length Good For 779k > 65

12WF161 - O.K. Total Load

Column Base PL Design - Interior:

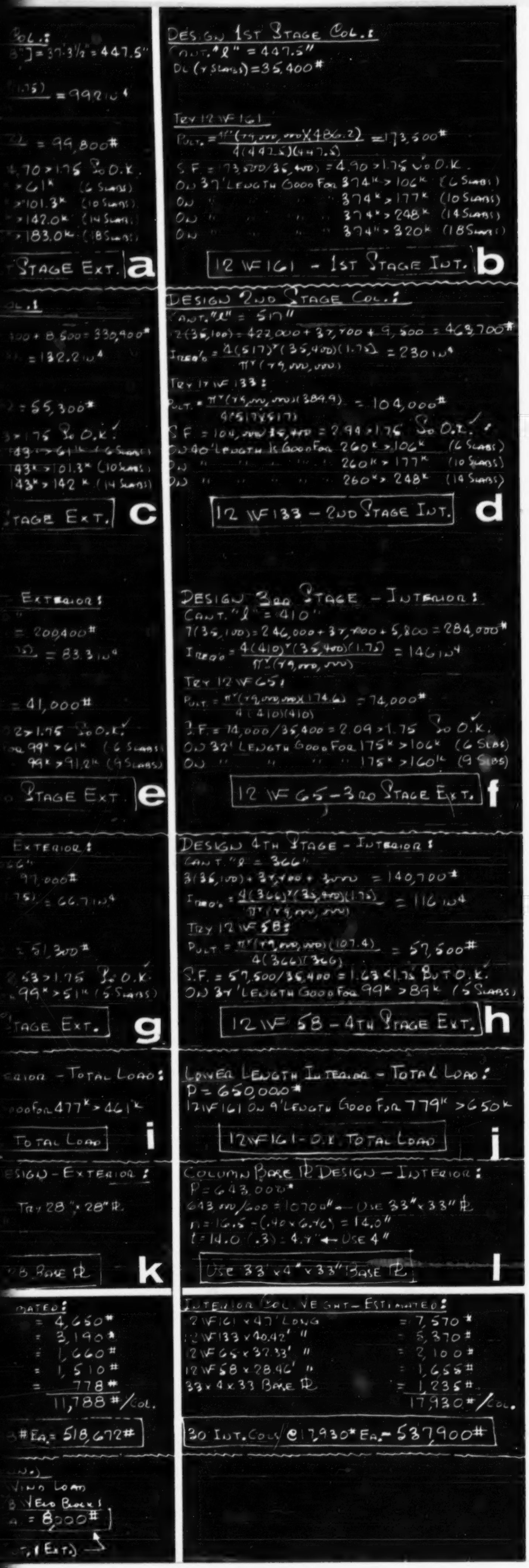
P = 643,000#
643,000/600 = 1070 □" ← Use 33" × 33" PL
n = 16.5 - (.40 × 6.46) = 14.0"
t = 14.0(.3) = 4.2" ← Use 4"

Use 33" × 4" × 33" Base PL

Interior Col. Weight - Estimated:

12WF161 × 47' Long	= 7,570#
12WF133 × 40.42' "	= 5,370#
12WF65 × 32.33' "	= 2,100#
12WF58 × 28.46' "	= 1,655#
33 × 4 × 33 Base PL	= 1,235#
	17,930#/C

30 Int. Cols @ 17,930# Ea. = 537,900#



COL.:
8"] = 37'-3½" = 447.5"
(1.75) = 99.2 IN⁴
= 99,800#
4.70 > 1.75 So O.K.
> 61k (6 SLABS)
> 101.3k (10 SLABS)
> 142.0k (14 SLABS)
> 183.0k (18 SLABS)
STAGE EXT.
a

DESIGN 1ST STAGE COL.:
CANT. "l" = 447.5"
DL (7 SLABS) = 35,400#
TRY 12 WF 161
$P_{ULT.} = \frac{\pi^2(29,000,000)(486.2)}{4(442.5)(447.5)} = 173,500\#$
S.F. = 173,500/35,400 = 4.90 > 1.75 So O.K.
ON 37' LENGTH GOOD FOR 374k > 106k (6 SLABS)
ON " " " " 374k > 177k (10 SLABS)
ON " " " " 374k > 248k (14 SLABS)
ON " " " " 374k > 320k (18 SLABS)
12 WF 161 - 1ST STAGE INT.
b

COL.:
+ 8,500 = 330,900#
= 132.2 IN⁴
= 55,300#
> 1.75 So O.K.
~~149k > 61k (6 SLABS)~~
143k > 101.3k (10 SLABS)
143k > 142k (14 SLABS)
STAGE EXT.
c

DESIGN 2ND STAGE COL.:
CANT. "l" = 517"
12(35,100) = 422,000 + 37,700 + 9,500 = 463,700#
$I_{REQ'D} = \frac{4(517)^2(35,400)(1.75)}{\pi^2(29,000,000)} = 230 \text{ IN}^4$
TRY 12 WF 133:
$P_{ULT.} = \frac{\pi^2(29,000,000)(389.9)}{4(517)(517)} = 104,000\#$
S.F. = 104,000/35,400 = 2.94 > 1.75 So O.K.
ON 40' LENGTH IS GOOD FOR 260k > 106k (6 SLABS)
ON " " " " 260k > 177k (10 SLABS)
ON " " " " 260k > 248k (14 SLABS)
12 WF 133 - 2ND STAGE INT.
d

EXTERIOR:
= 200,400#
= 83.3 IN⁴
= 41,000#
2 > 1.75 So O.K.
FOR 99k > 61k (6 SLABS)
99k > 91.2k (9 SLABS)
STAGE EXT.
e

DESIGN 3RD STAGE - INTERIOR:
CANT. "l" = 410"
7(35,100) = 246,000 + 37,700 + 5,800 = 284,000#
$I_{REQ'D} = \frac{4(410)^2(35,400)(1.75)}{\pi^2(29,000,000)} = 146 \text{ IN}^4$
TRY 12 WF 65:
$P_{ULT.} = \frac{\pi^2(29,000,000)(174.6)}{4(410)(410)} = 74,000\#$
S.F. = 74,000/35,400 = 2.09 > 1.75 So O.K.
ON 32' LENGTH GOOD FOR 175k > 106k (6 SLBS)
ON " " " " 175k > 160k (9 SLBS)
12 WF 65 - 3RD STAGE EXT.
f

EXTERIOR:
66"
97,000#
(1.75) = 66.7 IN⁴
= 51,300#
53 > 1.75 So O.K.
99k > 51k (5 SLABS)
STAGE EXT.
g

DESIGN 4TH STAGE - INTERIOR:
CANT. "l" = 366"
3(36,100) + 37,400 + 3,000 = 140,700#
$I_{REQ'D} = \frac{4(366)^2(35,400)(1.75)}{\pi^2(29,000,000)} = 116 \text{ IN}^4$
TRY 12 WF 58:
$P_{ULT.} = \frac{\pi^2(29,000,000)(107.4)}{4(366)(366)} = 57,500\#$
S.F. = 57,500/35,400 = 1.63 < 1.75 BUT O.K.
ON 37' LENGTH GOOD FOR 99k > 89k (5 SLABS)
12 WF 58 - 4TH STAGE EXT.
h

ERIOR - TOTAL LOAD:
GOOD FOR 477k > 461k
TOTAL LOAD
i

LOWER LENGTH INTERIOR - TOTAL LOAD:
P = 650,000#
12 WF 161 ON 9' LENGTH GOOD FOR 779k > 650k
12 WF 161 - O.K. TOTAL LOAD
j

ESIGN - EXTERIOR:
TRY 28" × 28" PL
8 BASE PL
k

COLUMN BASE PL DESIGN - INTERIOR:
P = 643,000#
643,000/600 = 1070 □" ← USE 33" × 33" PL
n = 16.5 - (.40 × 6.46) = 14.0"
t = 14.0 (.3) = 4.2" ← USE 4"
USE 33" × 4" × 33" BASE PL
l

MATED:
= 4,650#
= 3,190#
= 1,660#
= 1,510#
= 778#
11,788#/COL.
#EA. = 518,672#

INTERIOR COL. WEIGHT - ESTIMATED:
12 WF 161 × 47' LONG = 7,570#
12 WF 133 × 40.42' " = 5,370#
12 WF 65 × 32.33' " = 2,100#
12 WF 58 × 28.46' " = 1,655#
33 × 4 × 33 BASE PL = 1,235#
17,930#/COL.
30 INT. COLS @ 17,930# EA. = 537,900#

WIND)
WIND LOAD
8 VERO BLOCK
A. = 8,000#
, 1 EXT.)

In the cost study, the following basic assumptions apply to all three structures:

1. Floor-to-floor heights set at 8'-1"; with 7" slabs 7'-6" clear.
2. Study based on "average" building height of 17 floors and roof — total height: 147'-0".
3. 18 slabs lifted on steel H columns as noted; 12, 14, WF.
4. In "A" and "B" connecting links with stairs and elevators are poured in place — rods tie into lifted slabs.
5. In "C" complete slab is lifted with required openings.
6. Cost of poured-in-place sections prorated per sq. ft. basis.
7. Foundations of each structure prorated per sq. ft. basis.
8. Exterior wall in all cases consists of precast concrete panels 5" thick (see Chapter Three); 1'-0" x 8'-1" panel weighs 330 lbs.
9. All slabs extend 6" beyond outside face of columns to hold lifting collars; with attached clips at slab edge to anchor exterior concrete panels.
10. No reduction of live load taken on any columns as design for wind bracing assumed to compensate for this.
11. Lightweight concrete used throughout at current N.Y.C. price (Spring 1958) of $22.46 net per cu. yd. in place.
12. All openings as dimensioned or noted.

The complete cost estimate is made up as follows:

A. Building "A" complete estimated. (photostat left)

B. Building "B" based on estimate A. (photostat)

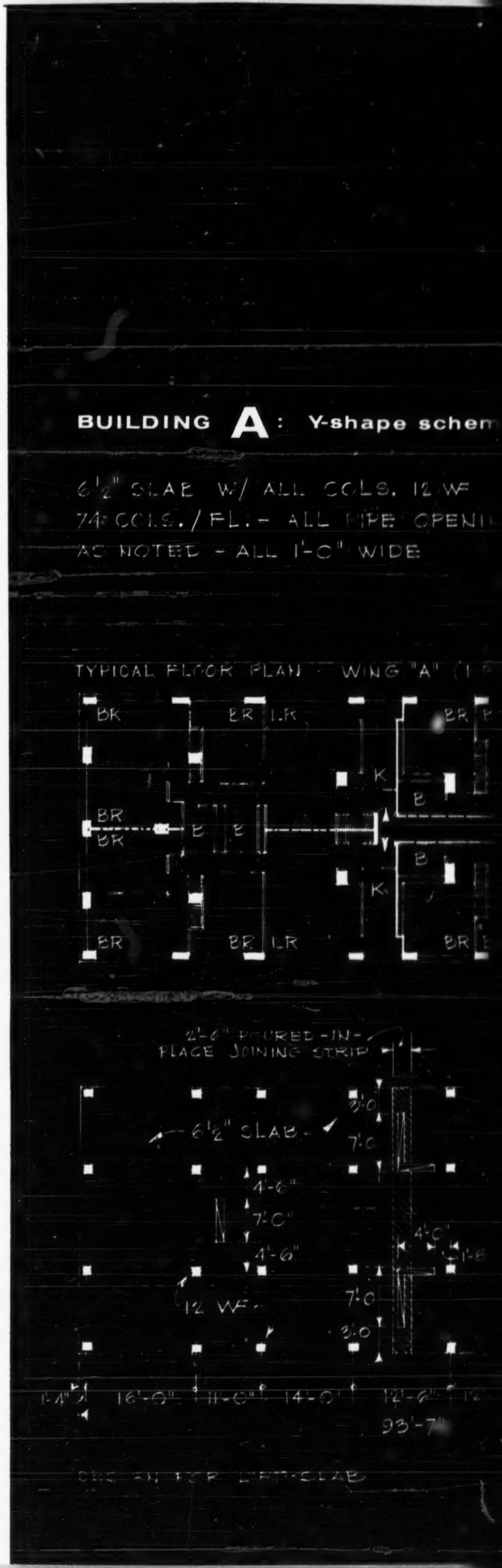
C. Building "C" based on estimate A. (photostat)

D. Quantity and cost take-off for each of three buildings. (See typed tabulations)

E. Summary and comparison to poured-in-place cost of Building "A."

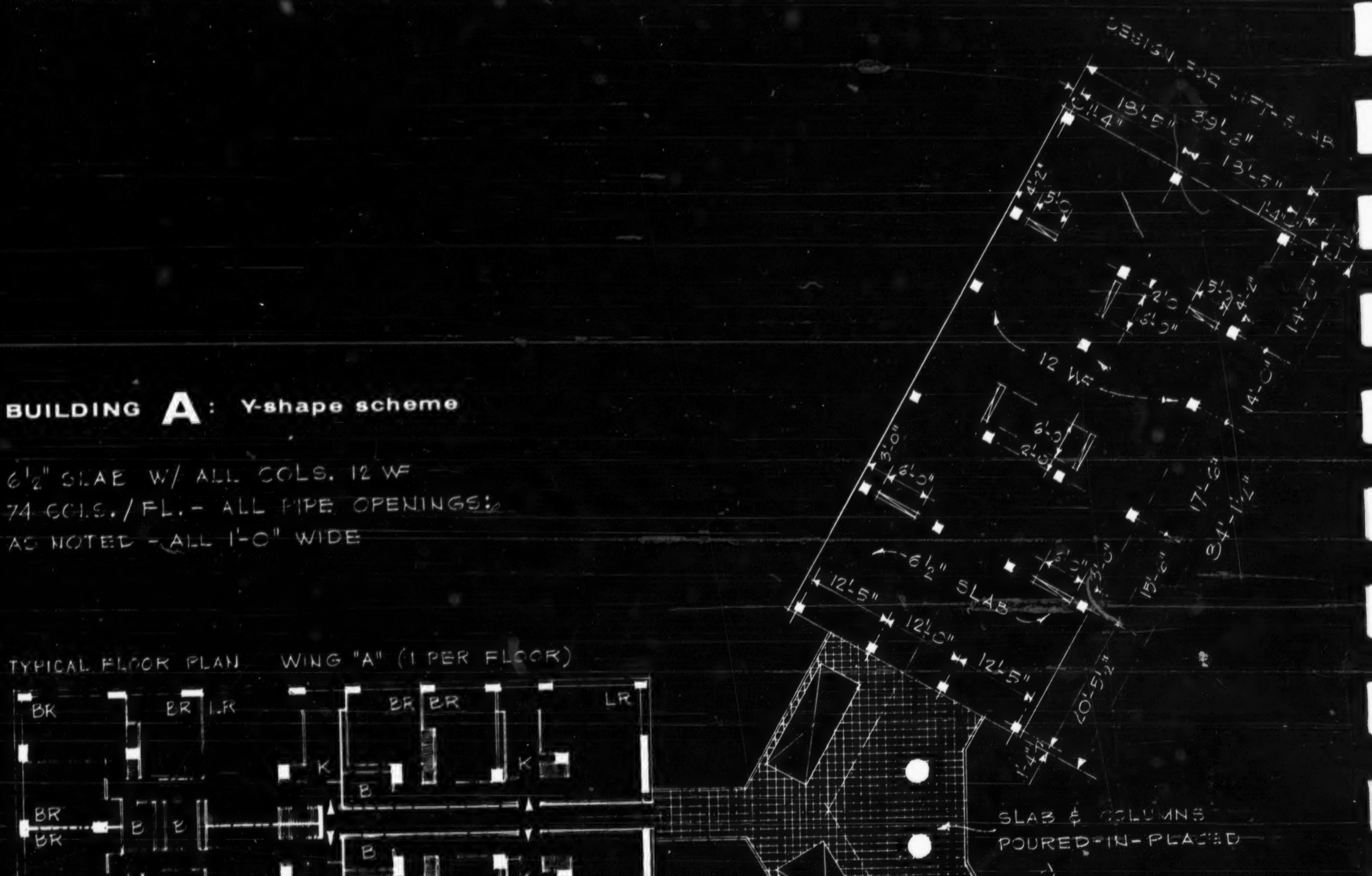
A Building "A"—"Y-shaped Building": Floor plan and cost data

A "Y-shaped" building of reinforced concrete presently under construction for New York State Division of Housing, slightly modified to line up columns (with no change in room sizes or apartment layout) for lift-slab. Slight inconvenience of placing some columns in middle of wall in a room not considered unreasonable for low-income public housing. Typical floor plan of three wings used. Average cost of structure as built used for comparison with all three structures erected by lift-slab.

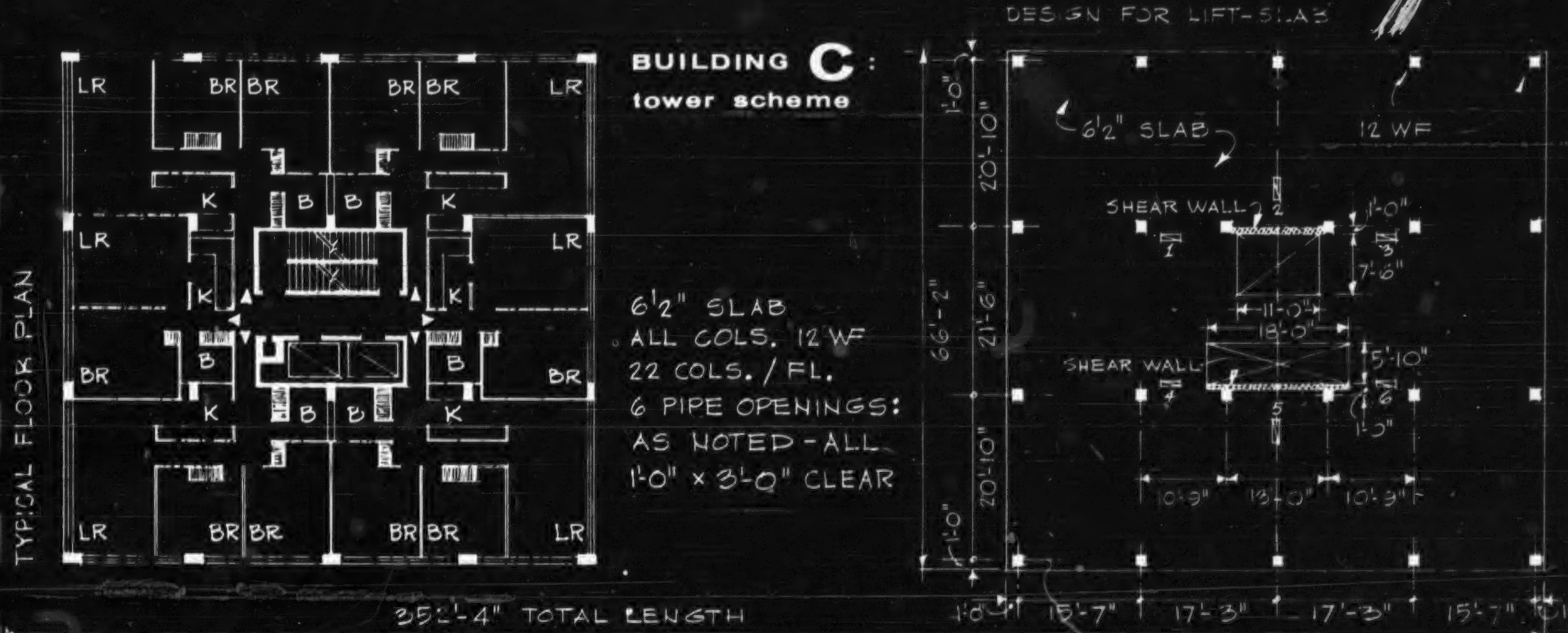

BUILDING A: Y-shape schem
6½" SLAB W/ ALL COLS. 12 WF
74 COLS./FL. – ALL PIPE OPENI
AS NOTED – ALL 1'-0" WIDE
TYPICAL FLOOR PLAN · WING "A"
BR
BR
LR
K
B
BR
BR
B
B
B
K
BR
BR
LR
BR
2'-6" POURED-IN-PLACE JOINING STRIP
6½" SLAB
3'-0
7'-0
4'-6"
7'-0"
4'-6"
4'-0"
1'-6
12 WF
7'-0
3'-0
1'-4"
16'-0"
11'-0"
14'-0"
12'-6"
93'-7"
DESIGN FOR LIFT-SLAB

BUILDING **A**: Y-shape scheme

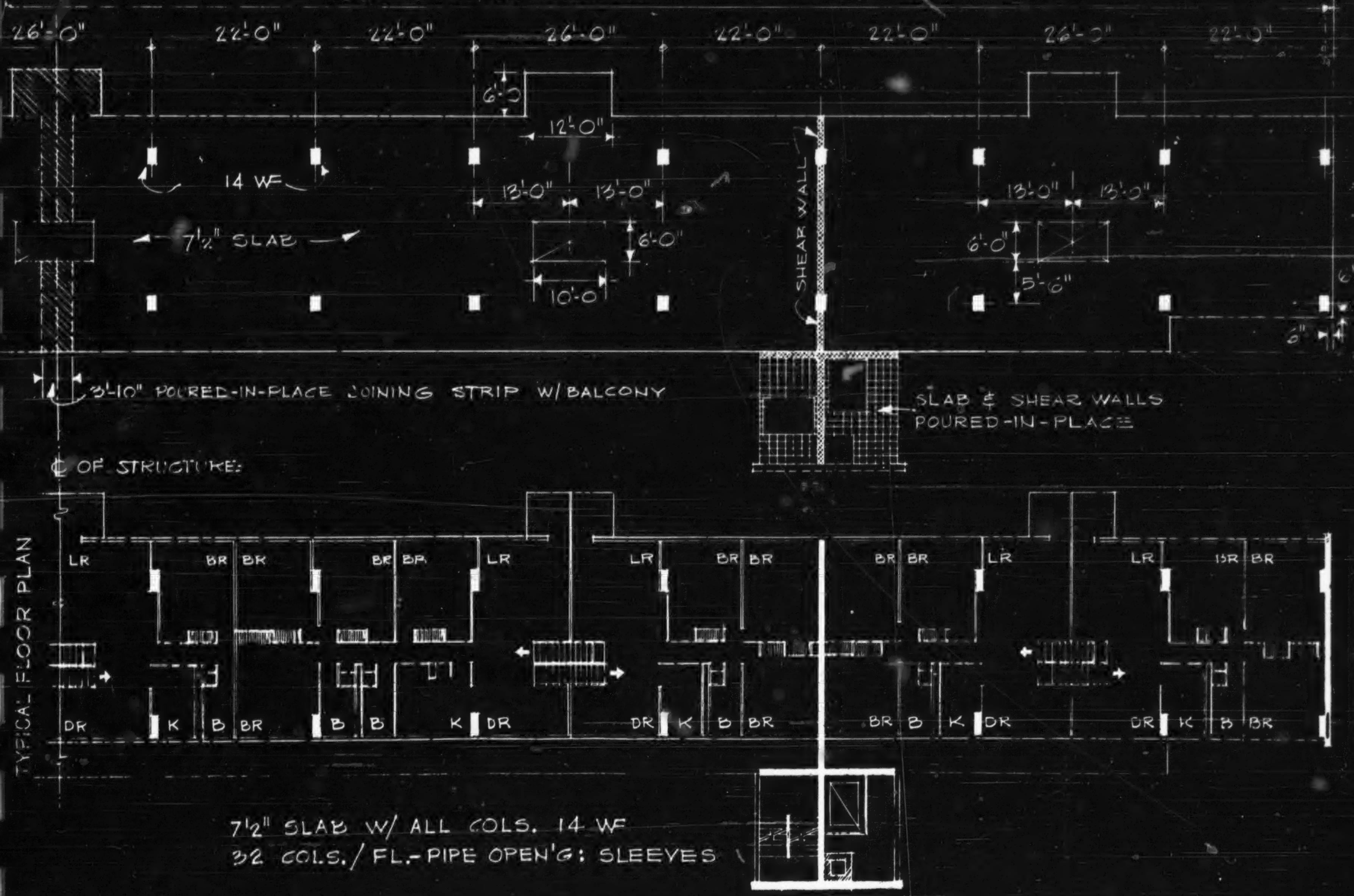
6½" SLAB W/ ALL COLS. 12 WF
74 COLS./FL. - ALL PIPE OPENINGS:
AS NOTED - ALL 1'-0" WIDE


DESIGN FOR LIFT-SLAB
1'4"
18'-5"
39'-6"
18'-5"
1'4"
4'2"
5'-0
2'-0
5'-0"
5'-0
4'-2
14'-0"
12 WF
6'-0
2'-0
3'-0"
6'-0"
17'-6"
34'-1½"
15'-6"
3'-0
6½" SLAB
12'-5"
12'-0"
12'-5"
20'-5½"
1'-4"
TYPICAL FLOOR PLAN WING "A" (1 PER FLOOR)
BR
LR
K
B
SLAB & COLUMNS
POURED-IN-PLACED
TYPICAL FLOOR PLAN WING "C" (2 PER FLOOR)
2'-6" POURED-IN-PLACE JOINING STRIP
43'-10"
6½" SLAB
3'-0
7'-0
4'-6"
7'-0"
4'-6"
12 WF
6'-0"
10'-4"
10'-4"
1'-8"
6'-0"
3'-0
1'-4
9'-9⅝"
16'-0"
9'-9⅝"
39'-3¼"
1'-4"
16'-0"
11'-0"
14'-0"
12'-6"
12'-6"
12'-6"
12'-5
1'-4"
93'-7"
DESIGN FOR LIFT-SLAB

BUILDING C: tower scheme

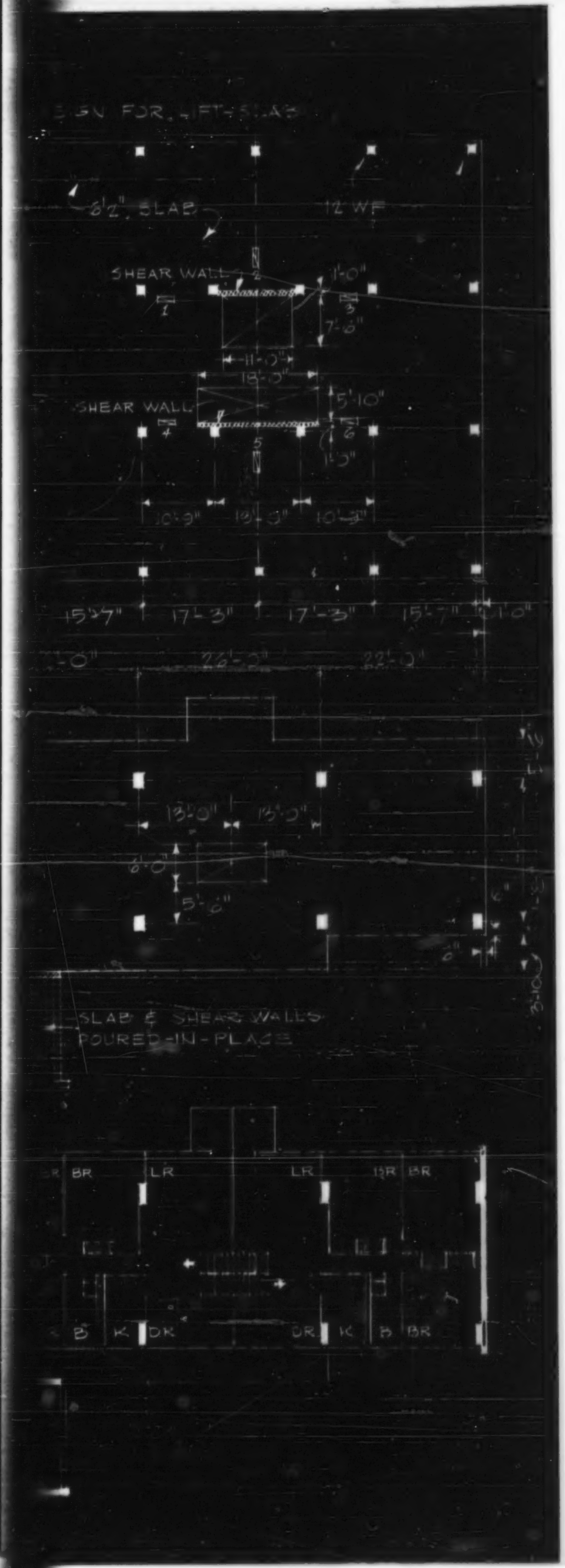

TYPICAL FLOOR PLAN
LR
BR BR
BR BR
LR
K
B B
K
LR
LR
K
K
BR
B
B
BR
K
B B
K
LR
BR BR
BR BR
LR
DESIGN FOR LIFT-SLAB
6½" SLAB
12 WF
SHEAR WALL 2
1
3
1'-0"
7'-6"
11'-0"
18'-0"
SHEAR WALL
4
5'-10"
5
6
1'-0"
10'-9"
13'-0"
10'-9"
1'-0"
20'-10"
21'-6"
66'-2"
20'-10"
1'-0"
1'0"
15'-7"
17'-3"
17'-3"
15'-7"

6½" SLAB
ALL COLS. 12 WF
22 COLS./FL.
6 PIPE OPENINGS:
AS NOTED - ALL
1'-0" × 3'-0" CLEAR


352'-4" TOTAL LENGTH
26'-0"
22'-0"
22'-0"
26'-0"
22'-0"
22'-0"
26'-0"
22'-0"
6'-0"
12'-0"
14 WF
7½" SLAB
13'-0"
13'-0"
6'-0"
10'-0"
SHEAR WALL
13'-0"
13'-0"
6'-0"
5'-6"
6"
3'-10" POURED-IN-PLACE JOINING STRIP W/ BALCONY
SLAB & SHEAR WALLS POURED-IN-PLACE
℄ OF STRUCTURE
TYPICAL FLOOR PLAN
LR
BR BR
BR BR
LR
LR
BR BR
BR BR
LR
LR
BR BR
DR
K
B
BR
B
B
K
DR
DR
K
B
BR
BR
B
K
DR
DR
K
B
BR

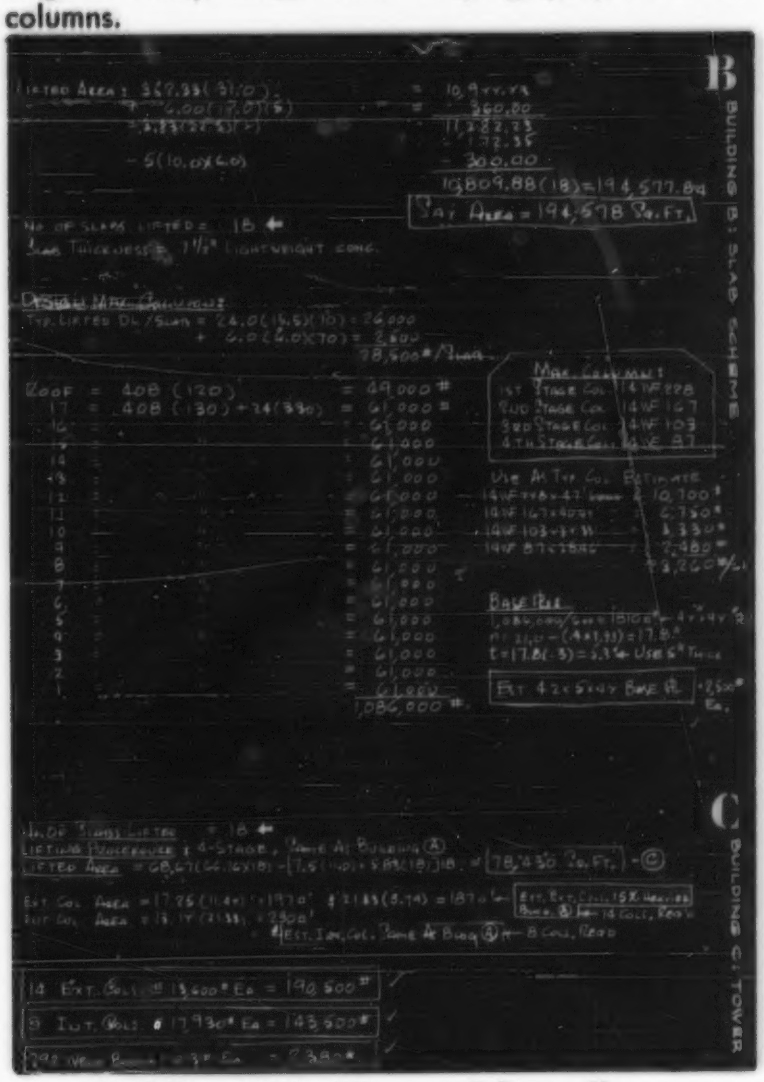
7½" SLAB W/ ALL COLS. 14 WF
32 COLS./FL. - PIPE OPEN'G: SLEEVES

BUILDING B: slab scheme


SIGN FOR LIFT-SLAB
8½" SLAB
12 WF
SHEAR WALL
1'-0"
7'-6"
11'-0"
18'-0"
SHEAR WALL
5'-10"
1'-5"
10'-9"
13'-5"
10'-9"
15'-7"
17'-3"
17'-3"
15'-7"
1'-0"
22'-0"
22'-0"
13'-0"
13'-0"
6'-0"
5'-6"
SLAB & SHEAR WALLS POURED-IN-PLACE
BR
BR
LR
LR
BR
BR
B
K
DR
DR
K
B
BR

B Building "B"—"Slab-Scheme": Floor plan and cost data

An Exterior-Corridor "Slab-Type" building studied in this report in section on "Plan Studies." Detailed study of a preliminary scheme recently submitted to New York State Division of Housing for consideration for a public housing project. In this case, study was based on many design and engineering requirements of lift-slab and so there has been very little modification of original study other than varying proportion of columns.


B

BUILDING B: SLAB SCHEME

10,809.88 (18) = 194,577.84

SAY AREA = 194,578 SQ. FT.

NO. OF SLABS LIFTED = 18

ROOF = 408 (120) = 49,000 #

17 = 408 (130) + 24 (330) = 61,000 #

1,086,000 #

C

BUILDING C: TOWER

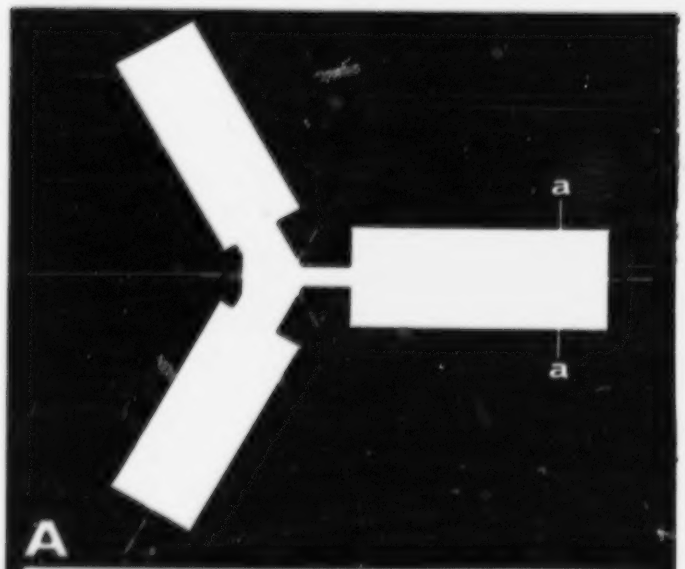
78,430 SQ. FT.

14 EXT. COLS. @ 13,600# EA = 190,500#

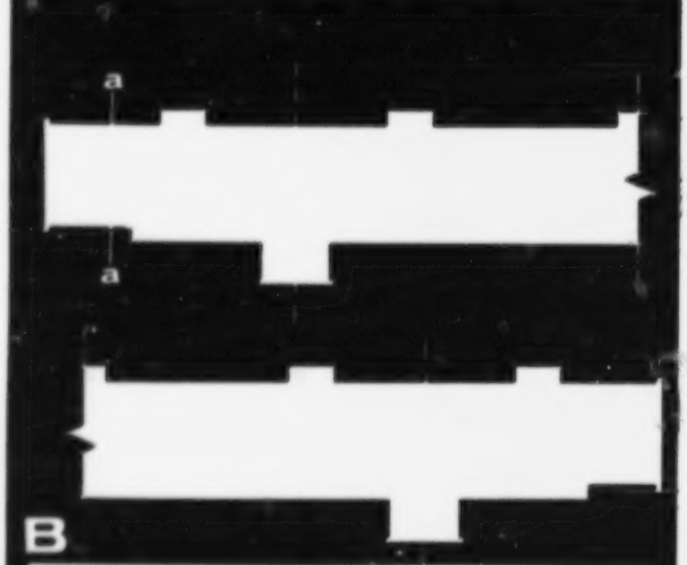
8 INT. COLS. @ 17,930# EA = 143,600#

C Building "C"—"Tower-Scheme": Floor plan and cost data

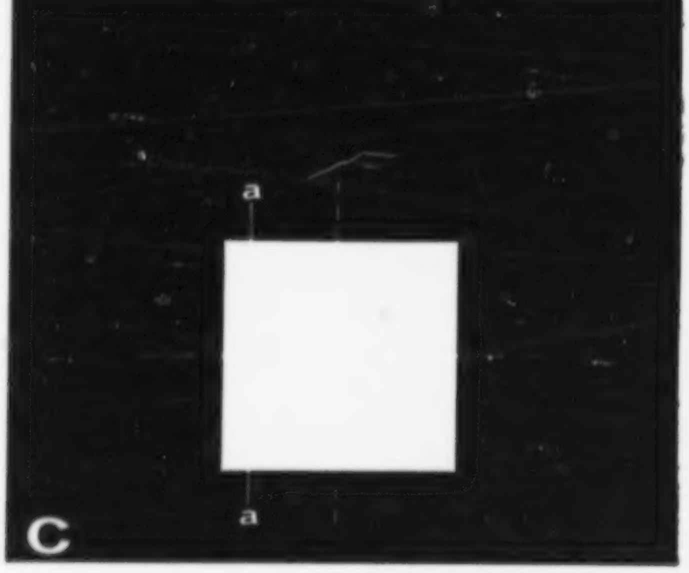
A "Tower-type" building making efficient use of minimum perimeter. Also part of study in this report in section on "Plan Studies." Only modification to this plan (well suited to lift-slab except that each slab is too small for maximum economy) was to add columns around stairwell and elevator opening.



A



B



C

D COST TAKE-OFF FOR EACH BUILDING

1. Lightweight concrete—185,000 SF - 6½" thick, in place
2. Reinforcing steel—185,000 SF @ av. 3.0# per SF
3. Columns (12WF)—518,672# + 537,900#, (528 T) in place
4. Weld blocks—8,000# of plate = 4 tons
5. Collars—74 x 18 floors = 1330
6. Roof float finish—10,300 SF
7. Floor finish—174,700 SF
8. Separator material—185,000 SF
9. Lifting and welding—185,000 SF
10. Miscellaneous forming—8,200 SF

---

1. Lightweight concrete—194,578 SF - 7½" thick, in place
2. Reinforcing steel—194,578 SF @ av. 4.5# per SF
3. Columns (14WF)—824,320#, (412 T) in place
4. Weld blocks—10,000# of plate = 5 tons
5. Collars—32 x 18 floors = 576
6. Roof float finish—10,810 SF
7. Floor finish—183,768 SF
8. Separator material—194,578 SF
9. Lifting and welding—194,578 SF
10. Miscellaneous forming—9,250 SF

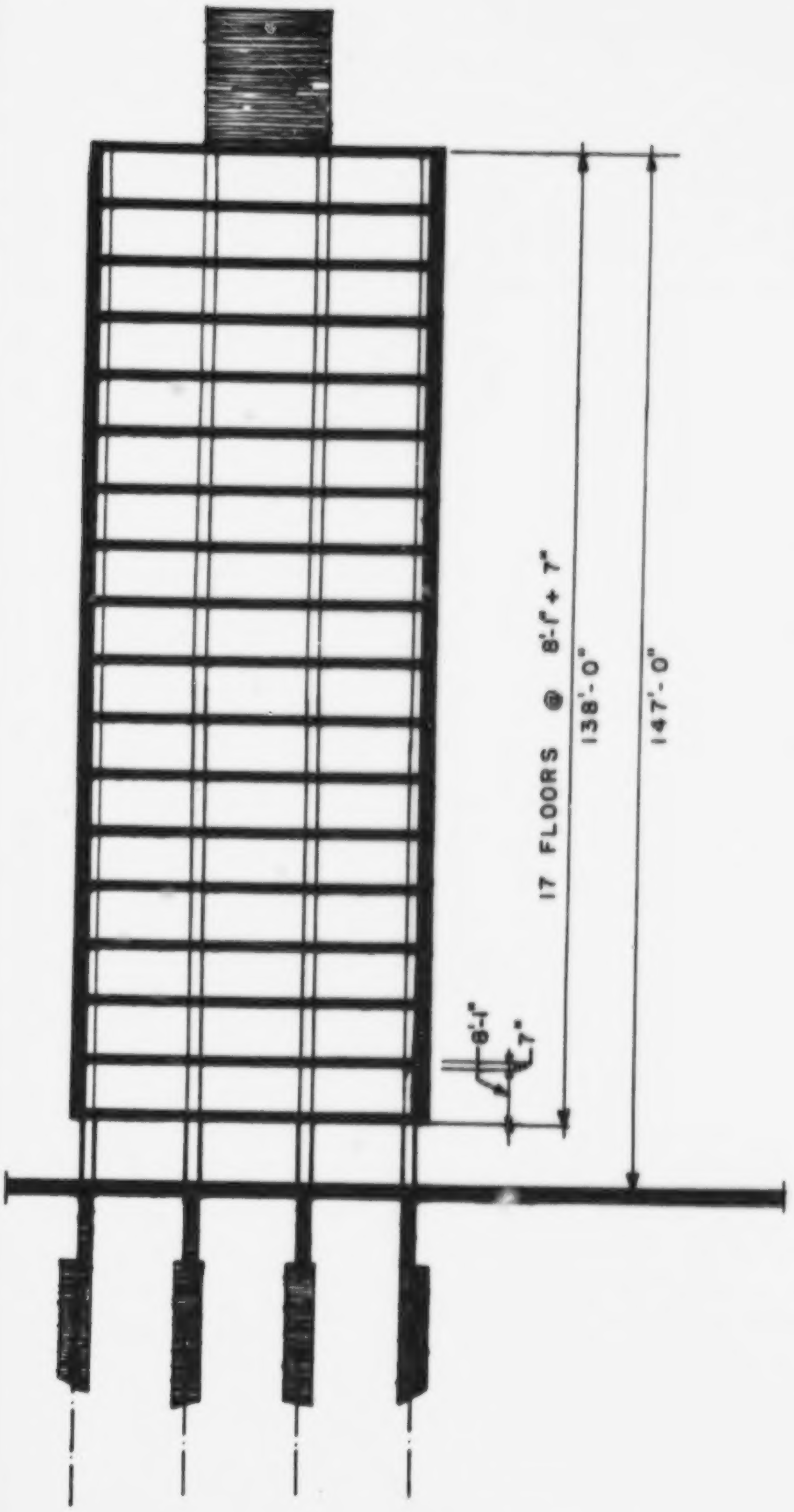
---

1. Lightweight concrete—78,430 SF - 6½" thick, in place
2. Reinforcing steel—78,430 SF @ av. 3.5# per SF
3. Columns (12WF)—190,500# + 143,500#, (167 T) in place
4. Weld blocks—2,380# of plate = 1.2 tons
5. Collars—22 x 18 floors = 396
6. Roof float finish—4,350 SF
7. Floor finish—74,080 SF
8. Separator material—78,430 SF
9. Lifting and welding—78,430 SF
10. Miscellaneous forming—2,630 SF

ghtweight concrete—185,000 SF - 6½" thick, in place	3,710	CY	@	$ 22.46	—	$ 83,327
inforcing steel—185,000 SF @ av. 3.0# per SF	278	T	@	280.00	—	77,840
olumns (12WF)—518,672# + 537,900#, (528 T) in place	528	T	@	250.00	—	132,000
eld blocks—8,000# of plate = 4 tons	4	T	@	225.00	—	900
ollars—74 x 18 floors = 1330	1,330	—	@	35.00	—	46,550
oof float finish—10,300 SF	10,300	SF	@	.10	—	1,030
oor finish—174,700 SF	174,700	SF	@	.13	—	22,711
eparator material—185,000 SF	185,000	SF	@	.03	—	5,550
fting and welding—185,000 SF	185,000	SF	@	.762	—	140,970
iscellaneous forming—8,200 SF	8,200	SF	@	1.00	—	8,200
						$519,028, or:
Subtotal						$2.81 per sq. ft.
8% for grouting, fireproofing,						.23
Subtotal						$3.04
10c per sq. ft., foundations						.10
Total						**$3.14 per sq. ft.**

ightweight concrete—194,578 SF - 7½" thick, in place	4,500	CY	@	$ 22.46	—	$101,070
einforcing steel—194,578 SF @ av. 4.5# per SF	437	T	@	280.00	—	122,360
Columns (14WF)—824,320#, (412 T) in place	412	T	@	250.00	—	103,000
Veld blocks—10,000# of plate = 5 tons	5	T	@	225.00	—	1,125
Collars—32 x 18 floors = 576	576	—	@	40.00	—	23,040
Roof float finish—10,810 SF	10,810	SF	@	.10	—	1,081
Floor finish—183,768 SF	183,768	SF	@	.13	—	23,890
Separator material—194,578 SF	194,578	SF	@	.03	—	5,837
Lifting and welding—194,578 SF	194,578	SF	@	.404	—	78,610
Miscellaneous forming—9,250 SF	9,250	SF	@	1.00	—	9,250
						$448,382, or:
Subtotal						$2.30 per sq. ft.
8% for grouting, fireproofing,						.19
Subtotal						$2.49
10c per sq. ft., foundations						.10
Total						**$2.59 per sq. ft.**

Lightweight concrete—78,430 SF - 6½" thick, in place	1,575	CY	@	$ 22.46	—	$ 35,375
Reinforcing steel—78,430 SF @ av. 3.5# per SF	137	T	@	280.00	—	38,360
Columns (12WF)—190,500# + 143,500#, (167 T) in place	167	T	@	250.00	—	41,750
Weld blocks—2,380# of plate = 1.2 tons	1.2	T	@	225.00	—	270
Collars—22 x 18 floors = 396	396	—	@	35.00	—	13,870
Roof float finish—4,350 SF	4,350	SF	@	.10	—	435
Floor finish—74,080 SF	74,080	SF	@	.13	—	9,630
Separator material—78,430 SF	78,430	SF	@	.03	—	2,353
Lifting and welding—78,430 SF	78,430	SF	@	.613	—	48,078
Miscellaneous forming—2,630 SF	2,630	SF	@	1.00	—	2,630
						$190,111, or:
Subtotal						$2.43 per sq. ft.
5% for grouting, fireproofing,						.12
Subtotal						$2.55
10c per sq. ft., foundations						.10
Total						**$2.65 per sq. ft.**



SECTION AA FOR BUILDINGS **A, B, C**

E A Summation of Lift-Slab Construction

From the above data, it will be noted that the most expensive of the three structures to erect with lift-slab was building "A" — redesigned from a standard concrete structure to lift-slab. If properly designed for lift-slab at the beginning, this structure could have been very economical — first wing formed and poured; second wing lifted; and third wing anchored in place. Lack of design for lift-slab from the beginning was accepted however so that this structure (under construction) could be used in cost comparison. The most economical was building "B" due largely to grid-like column layout, good bay sizes, good lifted slab sizes (2 lifts each of about 5500 sq. ft.), and low number of columns (hence fewer costly column collars per floor).

As a cost comparison, a review was made during field interviews and discussions with engineers and cost consultants on the approximate cost in New York City of a poured-in-place reinforced concrete frame structure. The price of the structure ("average public housing project"), complete, ran from $3.05 to $3.35 per sq. ft. of supported slab. We have, therefore:

Standard structure: **(poured-in-place)**	**$3.20 per sq. ft.**
Lift slab method:	
Building "A":	**$3.14 per sq. ft.**
Building "B":	**$2.59 per sq. ft.**
Building "C":	**$2.65 per sq. ft.**

What is not indicated in the above costs are the many added advantages derived from the lift-slab buildings in addition to "lower-than-average" construction costs for the frame in place. One of them in particular is the reduced construction time from beginning to end of the forming and lifting operation:

Building "A" — 30 weeks

Building "B" — 13 weeks

Building "C" — 8 weeks

ation of Lift-Slab Construction

above data, it will be noted that the most of the three structures to erect with lift-slab ng "A" — redesigned from a standard concture to lift-slab. If properly designed for t the beginning, this structure could have y economical — first wing formed and cond wing lifted; and third wing anchored Lack of design for lift-slab from the begin- accepted however so that this structure struction) could be used in cost comparison. economical was building "B" due largely to olumn layout, good bay sizes, good lifted (2 lifts each of about 5500 sq. ft.), and low columns (hence fewer costly column collars

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d structure: in-place)	**$3.20 per sq. ft.**
method:	
ling "A":	**$3.14 per sq. ft.**
ling "B":	**$2.59 per sq. ft.**
ling "C":	**$2.65 per sq. ft.**

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ling "A" — 30 weeks

ling "B" — 13 weeks

ling "C" — 8 weeks

Add to this the definite promise of even lower costs within the near future for lift-slab construction, and it can be readily seen why this method of construction must be given careful consideration by the Division of Housing as soon as possible. There are many problems attached to this system of building — as there were in steel framing and in conventional reinforced concrete — but it promises to have a bright future and its economies can not easily be refuted or neglected for long.

In the meantime, the Division of Housing should lay the ground work for the final acceptance of lift-slab construction:

Test the method in a project structure — for instance, in a low-rise building upstate or on Staten Island — right now.

Establish at an early stage basic design and engineering standards for the successful use of lift-slab in public housing.

Educate contractors (general and all subs) to the many advantages that each trade can derive (yes, even the carpenters in added public housing work made possible by reduced costs) from this system.

Investigate what changes, if any, are required in the various local and national codes to permit the full development of lift-slab, and initiate an early start toward those changes.

There appears to be no reason why the first lift-slab public housing structure should not be erected within the next three to five years. It will go up only because it will prove to be a more economical structure to erect. That fact alone should make New York State interested in having that structure erected under its sponsorship and supervision.

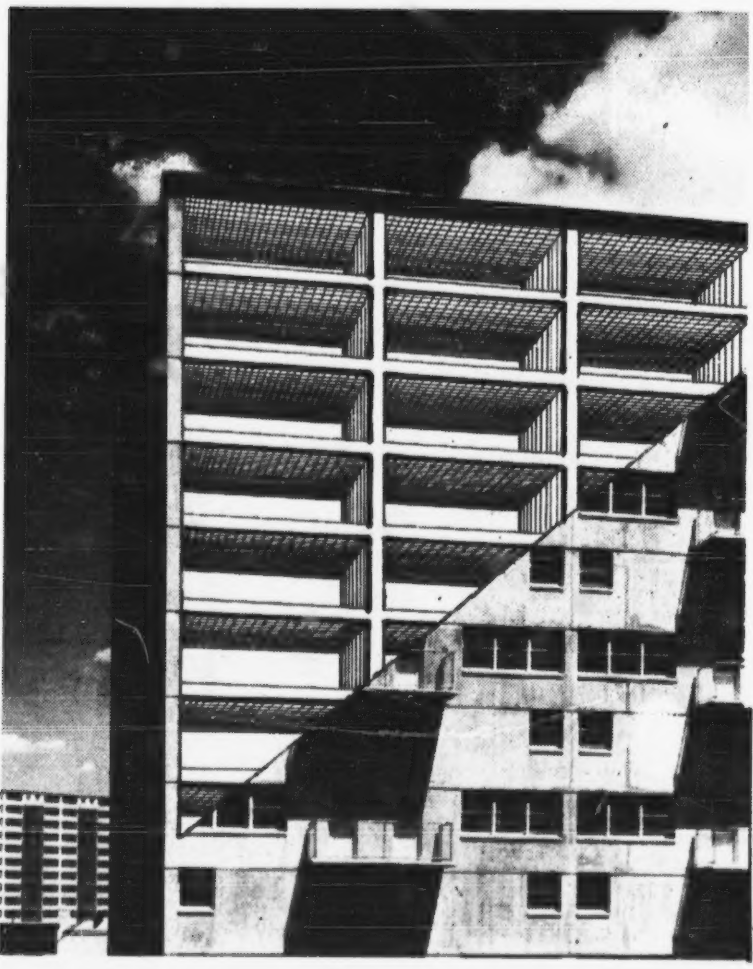
3 BOX-FRAME CONSTRUCTION

The "box-frame" system of construction is a relatively new building technique in the United States. However, in Europe, especially England, Russia and the Scandinavian countries, it is a common method of construction for high-rise buildings. The reason for this trend toward the box-frame is the economy involved in such a structure. In these countries, the lack of an immediate supply of steel made it a necessity to develop a structural system based on native materials. Concrete, being in abundance, was developed as the major framing material. Because of its plastic character, it has lent itself with ease to the development of precasting techniques. From this development of pre-cast integral parts, the precast box-frame became the next logical step in the development of the structure.

Advantages:

The advantages of the box-frame are many. One is the ability of the system to resist any wind forces acting upon it. Horizontal displacement of one story with respect to another is prevented in a skeleton frame by shear across the columns. In the box-frame, it is prevented by friction of wall on floor making movement negligible because of the sheer weight of the wall. In effect each wall acts as a solid plate, stiffened by the floor system. Because of this integral system of wind bracing; the overall sway of the structure is greatly reduced, if not entirely eliminated. The economies involved here become most significant. Long range savings occur in maintenance. Such common repair headaches as cracked partitions, sprung doors, damaged window frames and the like, resulting directly from the movement of the structure, are eliminated. The structural elements in themselves are fireproof resulting in a completely fireproof structure; this eliminates the necessity for any additional fireproofing. Foundation problems, where soil does not have much bearing capacity, are greatly improved because the total load of the building is distributed over a much larger area. In the system there is also the added advantage that the bearing walls between apartments give excellent sound insulation (60 decibel reduction for a 9" wall).

The first example of box-frame construction in the United States is the Hartford Park public housing development in Providence, R. I. Though this system was cast in place the structural principles are the same. The savings realized on this project have already been published and clearly show the marked economies of this system.



Architectural Forum
February, 1954; pgs. 164-167

In this section we present:

1. The planning requirements for box-frame construction, based on a current New York City housing project, with suggested cost saving details.
2. A study of exterior elevation treatment for buildings built by the box-frame method. This will be in two parts — first, proposed elevation studies and second, a perspective rendering showing a public housing structure erected by the box-frame method.

ges:

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second, a perspective rendering showing a
c housing structure erected by the box-frame
od.

Economies:

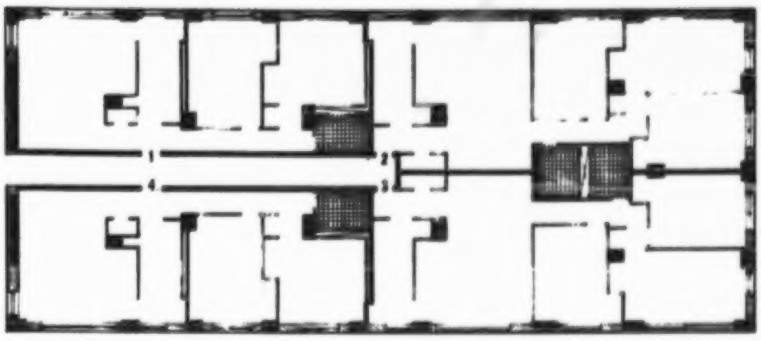
With development of pre-casting techniques, the economies and other advantages of the box-frame became obvious. The virtual elimination of formwork is one of the first cost savings involved. Mass production of the structural components, the pre-casting of standard size units, either factory-cast or cast-at-the-site, is another cost saving feature. The ease of erection of the pre-cast units greatly reduces construction time and thus reduces the cost of the structure. Whole sections of exterior walls (adequately insulated as shown in Chapter Three), as well as partitions and floors, can be erected and placed in record time. We can see from the savings mentioned above that this system should be further investigated as a possible building method in the near future.

Theory:

This system of construction is based on the theory that vertical members, since they outnumber and are larger in total area than horizontal elements, might logically be precast with considerable economy. By making these vertical members load-bearing, the need for a structural frame could be completely eliminated. Certain of the interior partitions (corridor walls, party walls and the like) would structurally support each floor. In like manner, each floor could be precast in sections and erected and joined to its carrying walls.

The Structure:

Structurally the system is very simple. In the standard skeleton frame construction all loads are transferred from floor slab to beams to girders to columns and thence down to the foundation. The loads are concentrated at each column. In the box-frame walls and partitions carry the load of the floor slabs without the use of columns or beams. Vertical panels are lifted into place by a crane, set on a bed of mortar and held in position with braces. Steel lifting eyes in the top edges of the panels provide anchorage when the floor or roof slab is lowered into position. The weight of this total structure is reduced by the use of light weight concrete.

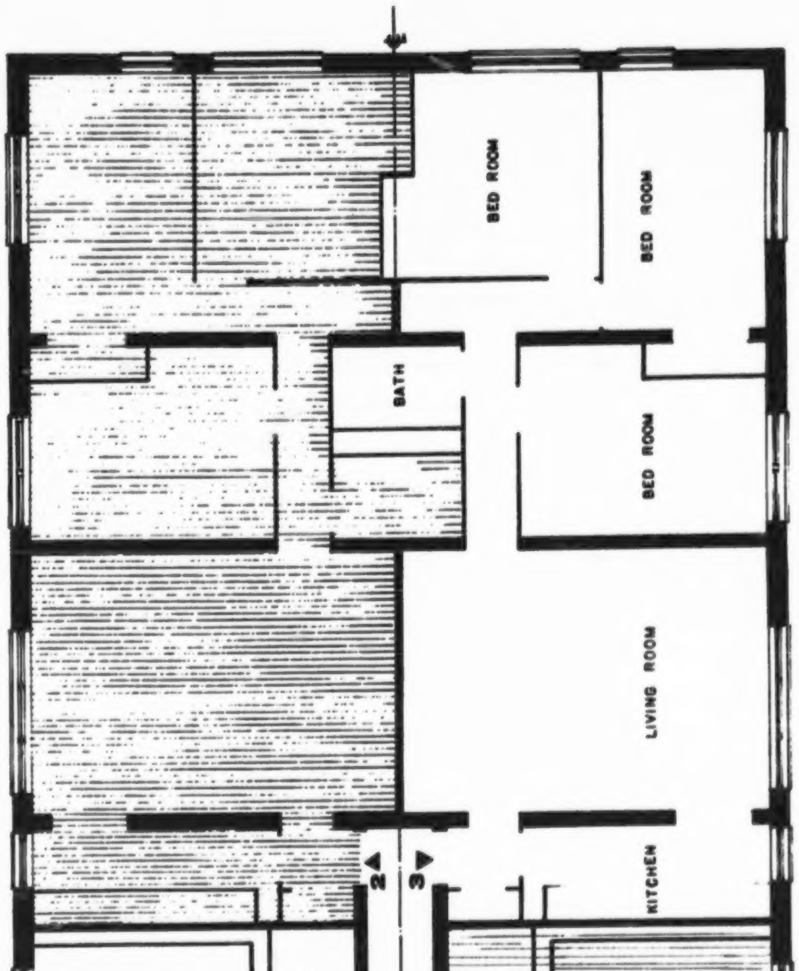


REDESIGN OF PLAN SHOWN A
FOR PRE-CAST BOX-FRAME STRU

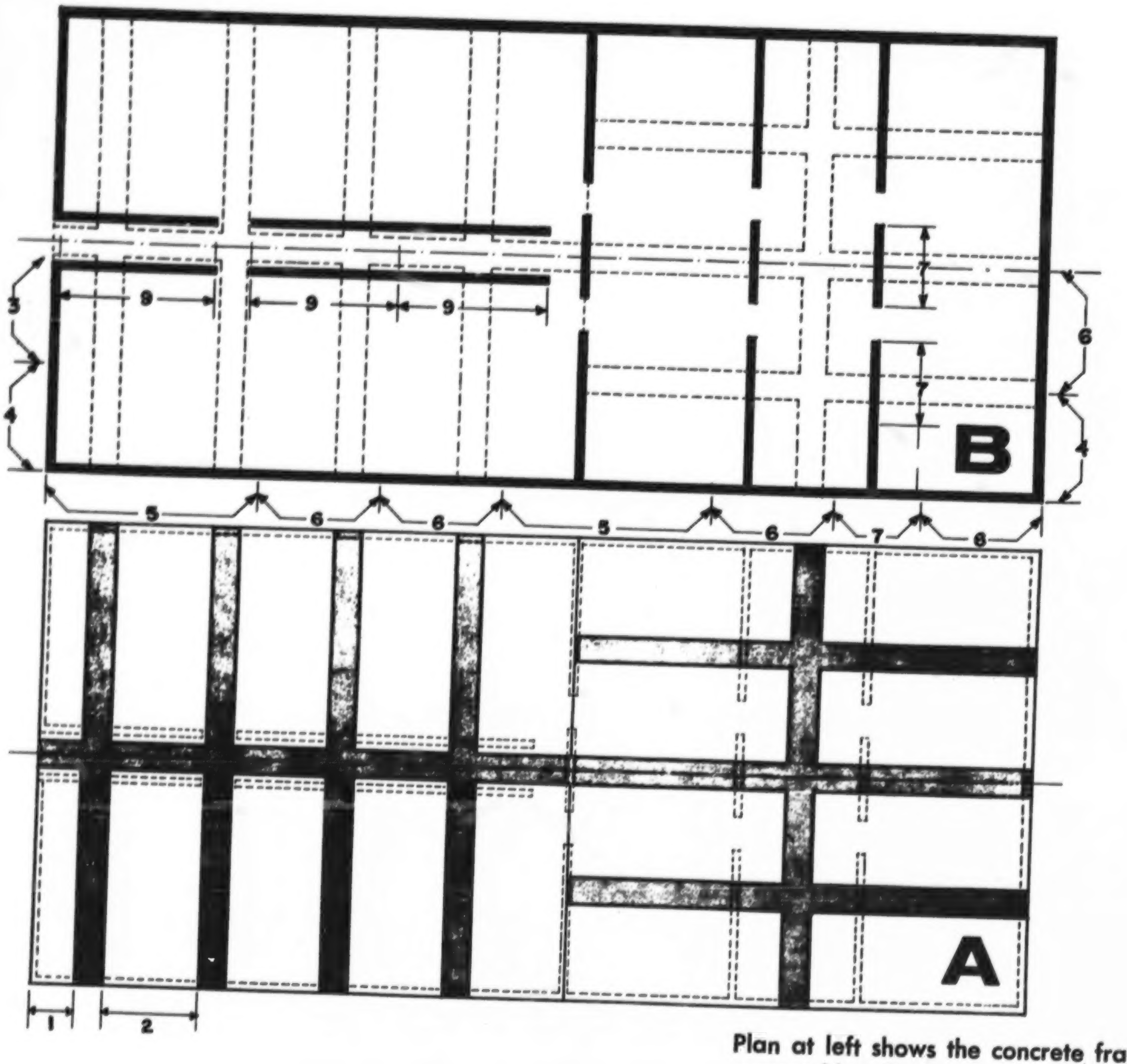
Planning for Box-frame Construction

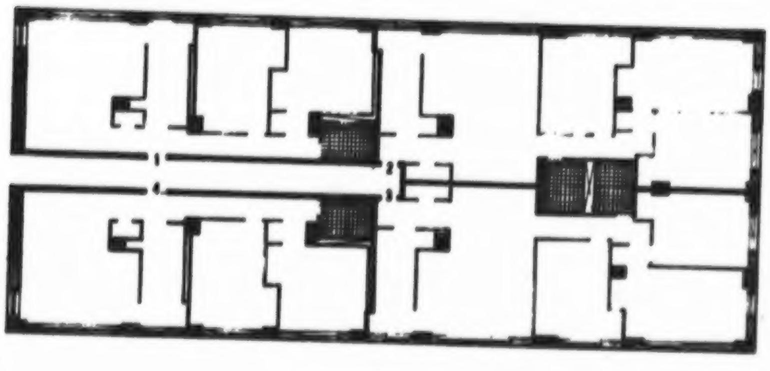
Diagram above indicates the floor plan of a current New York City housing project. The plan right shows the application of the precast box-frame system to this basic floor plan. The heavy partitions in the plan indicate the position of the load bearing elements. The bathrooms have been changed to a suggested 4'-6" width to show how this size would work in a typical apartment layout. By the application of this structural system it will be noticed that almost all jogs in the basic floor plan as shown at the left have been removed without altering the required size of the rooms. There is now a series of clearly articulated spaces formed because of the elimination of columns from these spaces. This is just one apartment type to which this structural system could be applied; it must be stated, however, that it is not the ideal plan type for the use of the box-frame. Ideally the box-frame would be applied to an apartment type where all the bearing walls would be cross walls forming a cellular, honeycomb-like structure into which the apartment rooms would nestle.

REDESIGN OF PLAN SHOWN AT LEFT
FOR PRE-CAST BOX-FRAME STRUCTURE


BED ROOM
BED ROOM
BATH
BED ROOM
LIVING ROOM
KITCHEN
2
3
BATH
BED ROOM
BED ROOM
PUBLIC HALL
1
4
KITCHEN
LIVING ROOM

PANEL TYPES USED IN CONSTRUCTION



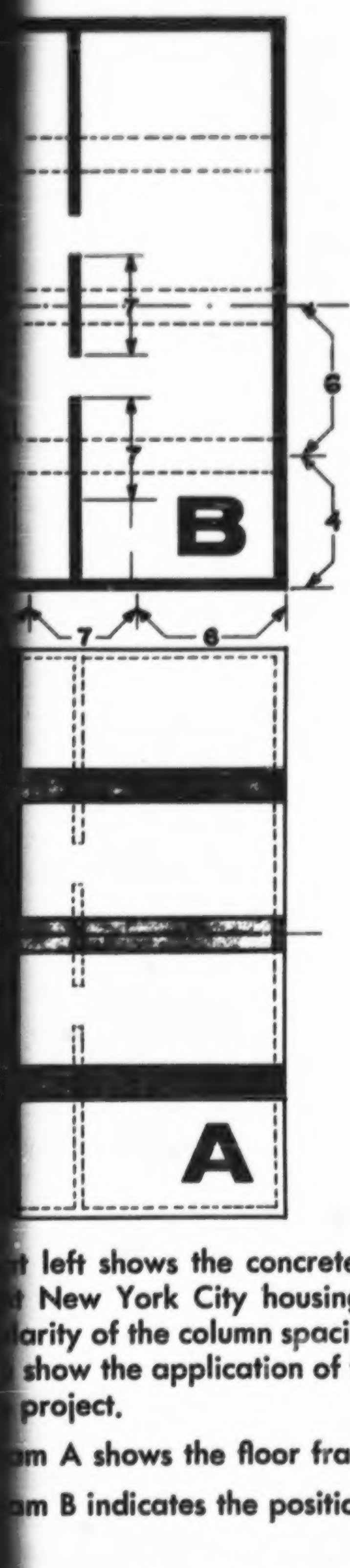


Plan at left shows the concrete framing system of a current New York City housing project. Notice the irregularity of the column spacing. The two diagrams above show the application of the box-frame method to this project.

Diagram A shows the floor framing system.

Diagram B indicates the position of the load bearing walls.

Both diagrams have been imposed on the structural framing plan as it was designed for the current New York City housing project with substantially no change in room or apartment layout.



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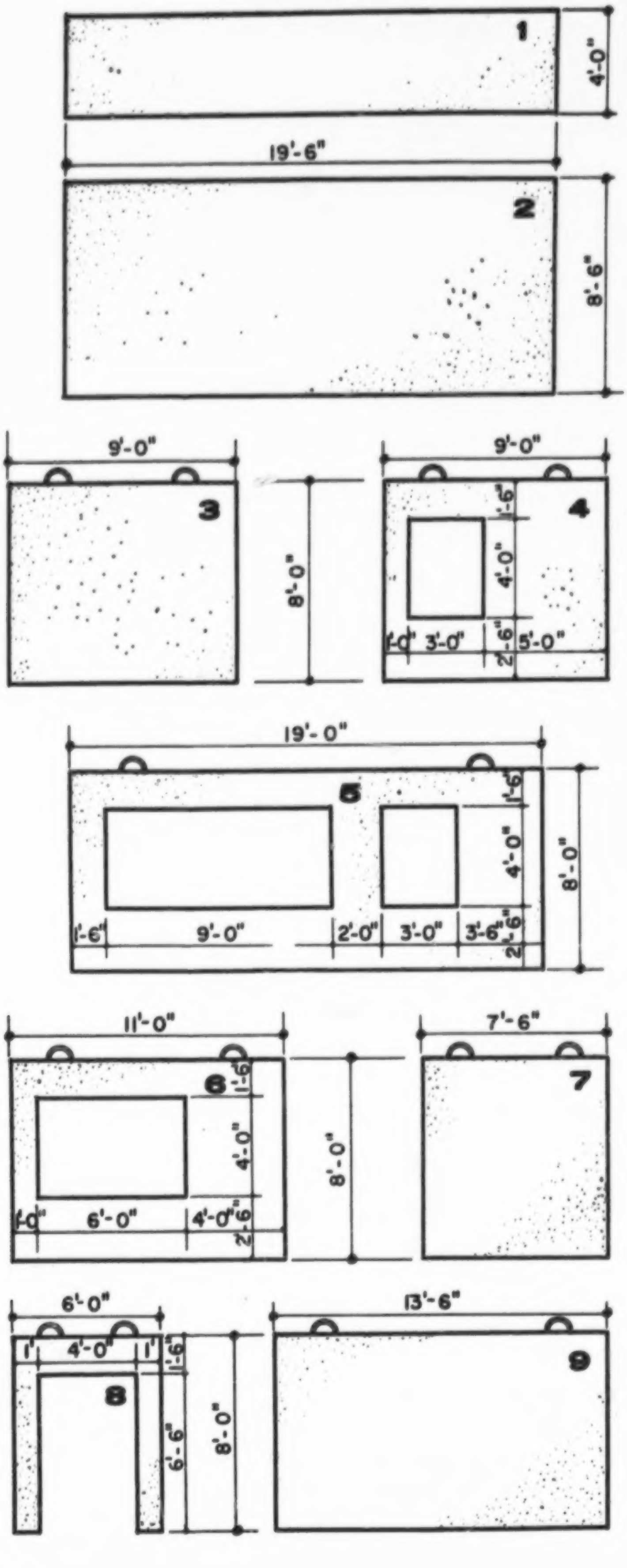
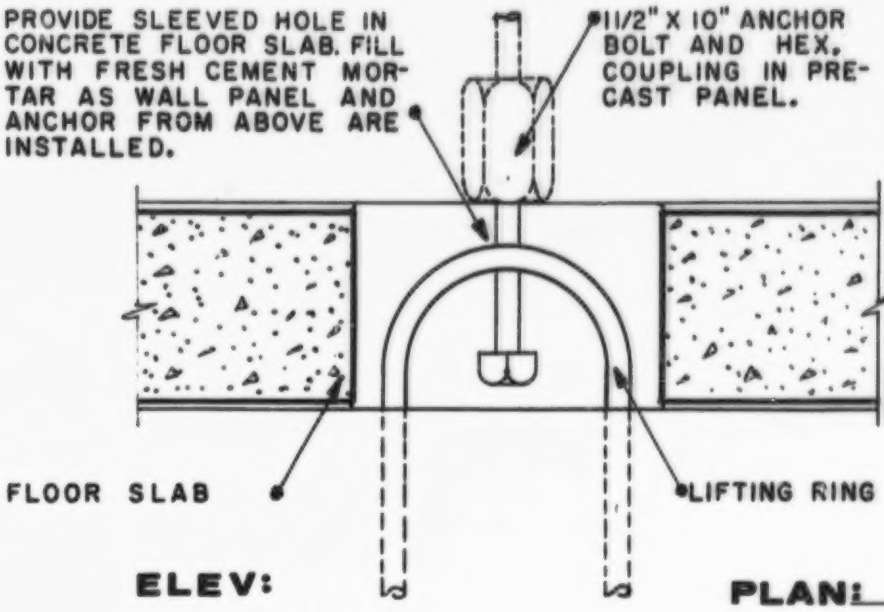
m A shows the floor framing system.

m B indicates the position of the load bearing

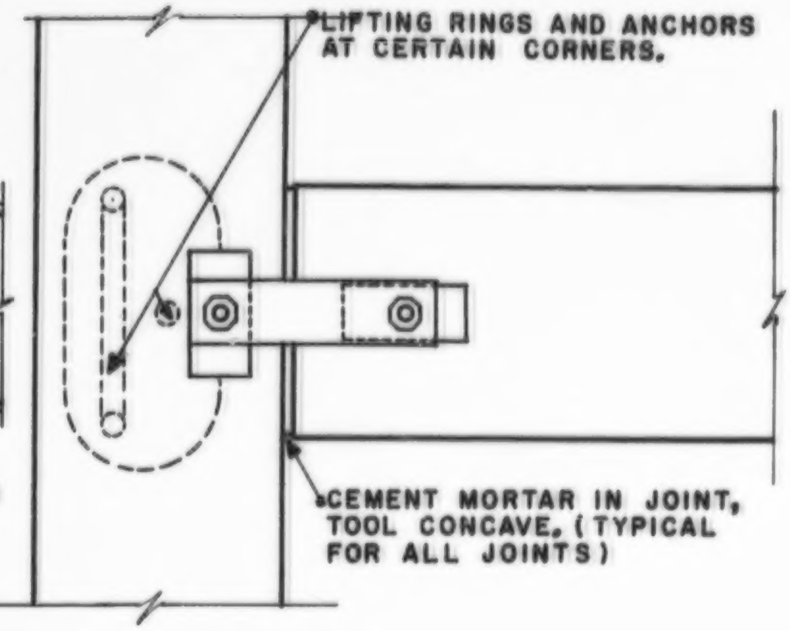
diagrams have been imposed on the structural g plan as it was designed for the current New City housing project with substantially no change n or apartment layout.

PANEL TYPES USED IN CONSTRUCTION

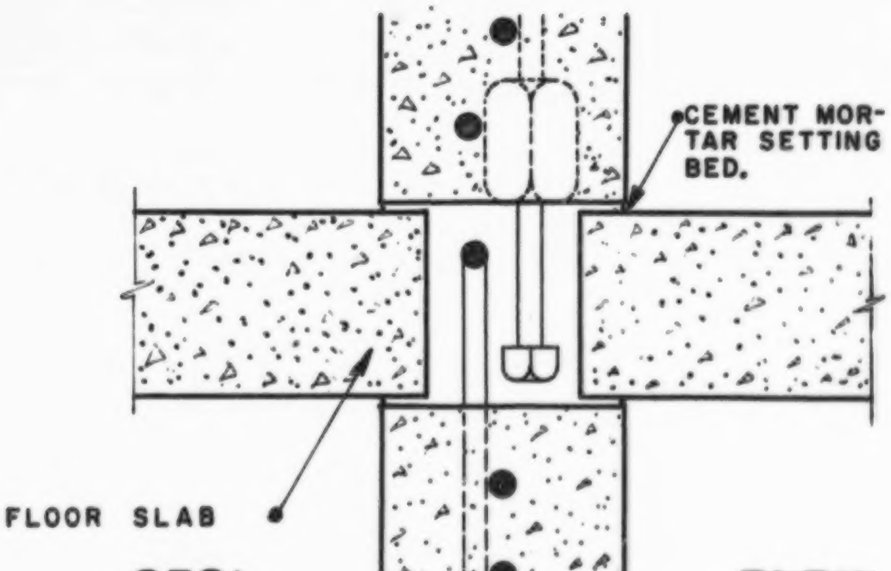

1
4'-0"
19'-6"
2
8'-6"
9'-0"
3
8'-0"
9'-0"
4
1'-6"
4'-0"
2'-6"
1'-0"
3'-0"
5'-0"
19'-0"
5
1'-6"
4'-0"
2'-6"
8'-0"
1'-6"
9'-0"
2'-0"
3'-0"
3'-6"
11'-0"
6
1'-6"
4'-0"
2'-6"
1'-0"
6'-0"
4'-0"
8'-0"
7'-6"
7
6'-0"
1'
4'-0"
1'
1'-6"
8
6'-6"
8'-0"
13'-6"
9


PROVIDE SLEEVED HOLE IN CONCRETE FLOOR SLAB. FILL WITH FRESH CEMENT MORTAR AS WALL PANEL AND ANCHOR FROM ABOVE ARE INSTALLED.
1 1/2" X 10" ANCHOR BOLT AND HEX. COUPLING IN PRECAST PANEL.
FLOOR SLAB
LIFTING RING

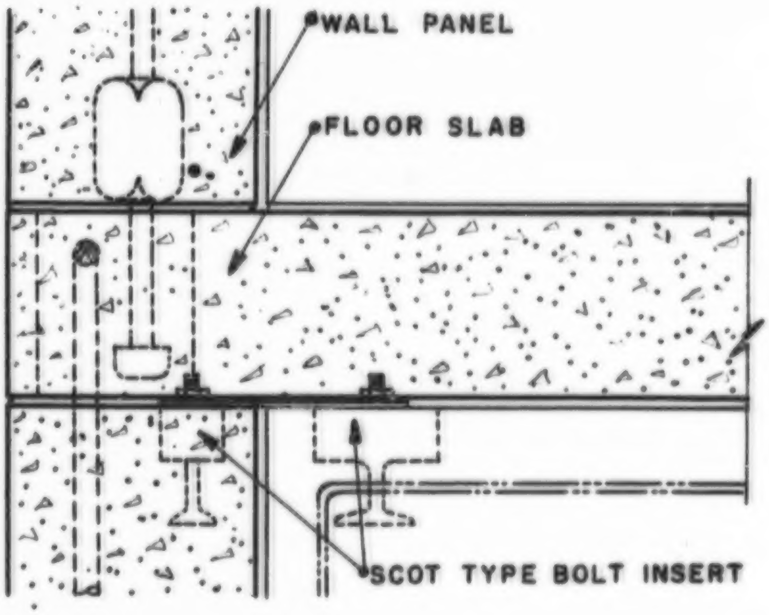
ELEV:


LIFTING RINGS AND ANCHORS AT CERTAIN CORNERS.
CEMENT MORTAR IN JOINT, TOOL CONCAVE. (TYPICAL FOR ALL JOINTS)

PLAN:


CEMENT MORTAR SETTING BED.
FLOOR SLAB

SEC:


WALL PANEL
FLOOR SLAB
SCOT TYPE BOLT INSERT

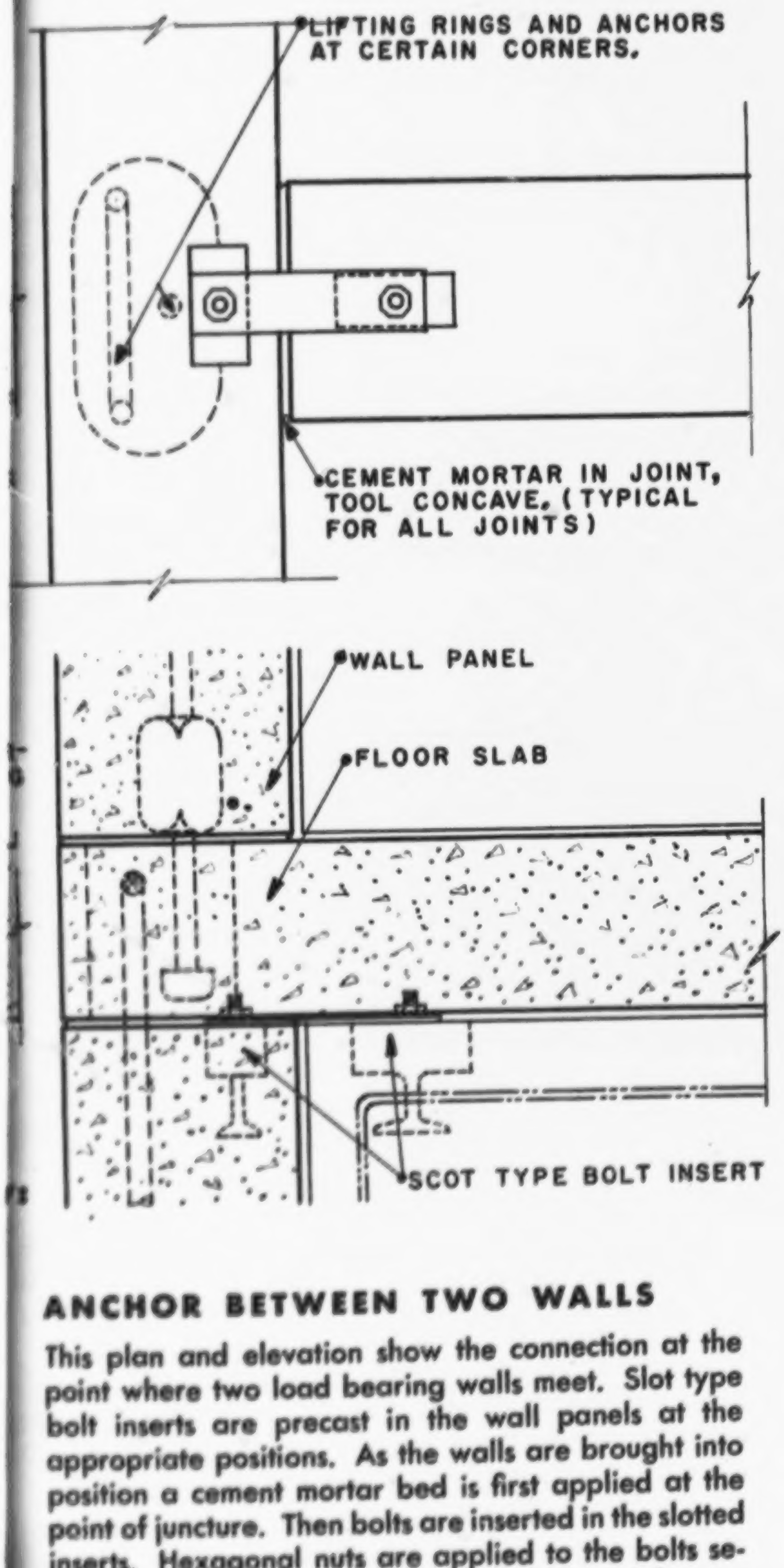
ELEV:

ANCHOR AT LIFTING RINGS

This elevation and section show the connection at the point where the lifting ring precast in the load bearing wall meets the adjoining floor slab. Notice that an anchor bolt is cast in the bottom of the wall above to secure it in the same jointing as the ring below. Mortar will fill the sleeved joint in the floor slab just prior to lowering the upper wall into position making the entire connection rigid and stable.

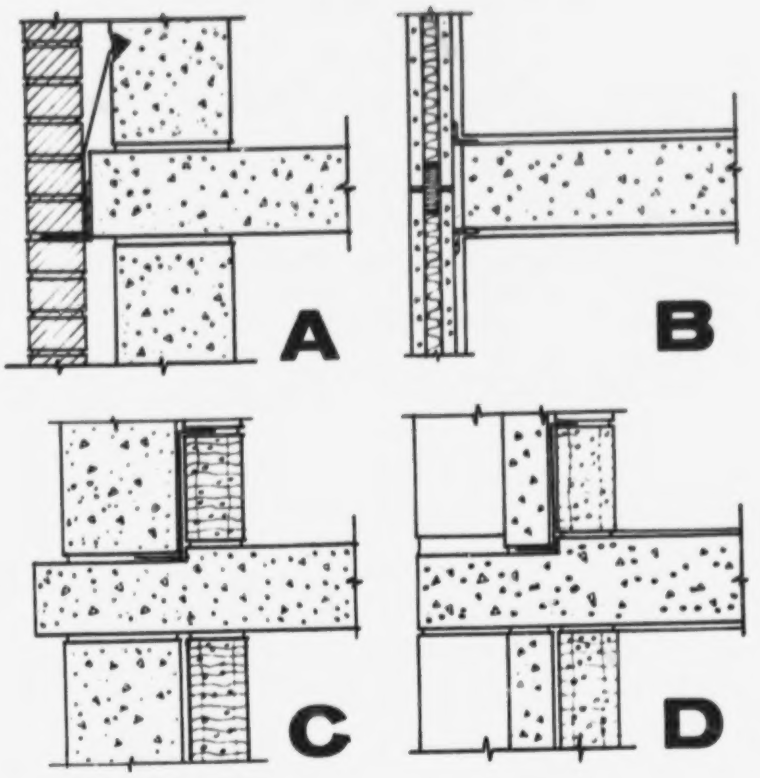
ANCHOR BETWEEN TWO WALLS

This plan and elevation show the connection at the point where two load bearing walls meet. Slot type bolt inserts are precast in the wall panels at the appropriate positions. As the walls are brought into position a cement mortar bed is first applied at the point of juncture. Then bolts are inserted in the slotted inserts. Hexagonal nuts are applied to the bolts securing the plate in position and making a tight connection between the walls.


LIFTING RINGS AND ANCHORS AT CERTAIN CORNERS.
CEMENT MORTAR IN JOINT, TOOL CONCAVE. (TYPICAL FOR ALL JOINTS)
WALL PANEL
FLOOR SLAB
SCOT TYPE BOLT INSERT

ANCHOR BETWEEN TWO WALLS

This plan and elevation show the connection at the point where two load bearing walls meet. Slot type bolt inserts are precast in the wall panels at the appropriate positions. As the walls are brought into position a cement mortar bed is first applied at the point of juncture. Then bolts are inserted in the slotted inserts. Hexagonal nuts are applied to the bolts securing the plate in position and making a tight connection between the walls.



SECTION A

This section shows the application of a standard brick veneer exterior over the box-frame structure as developed around a current New York City housing project.

SECTION B

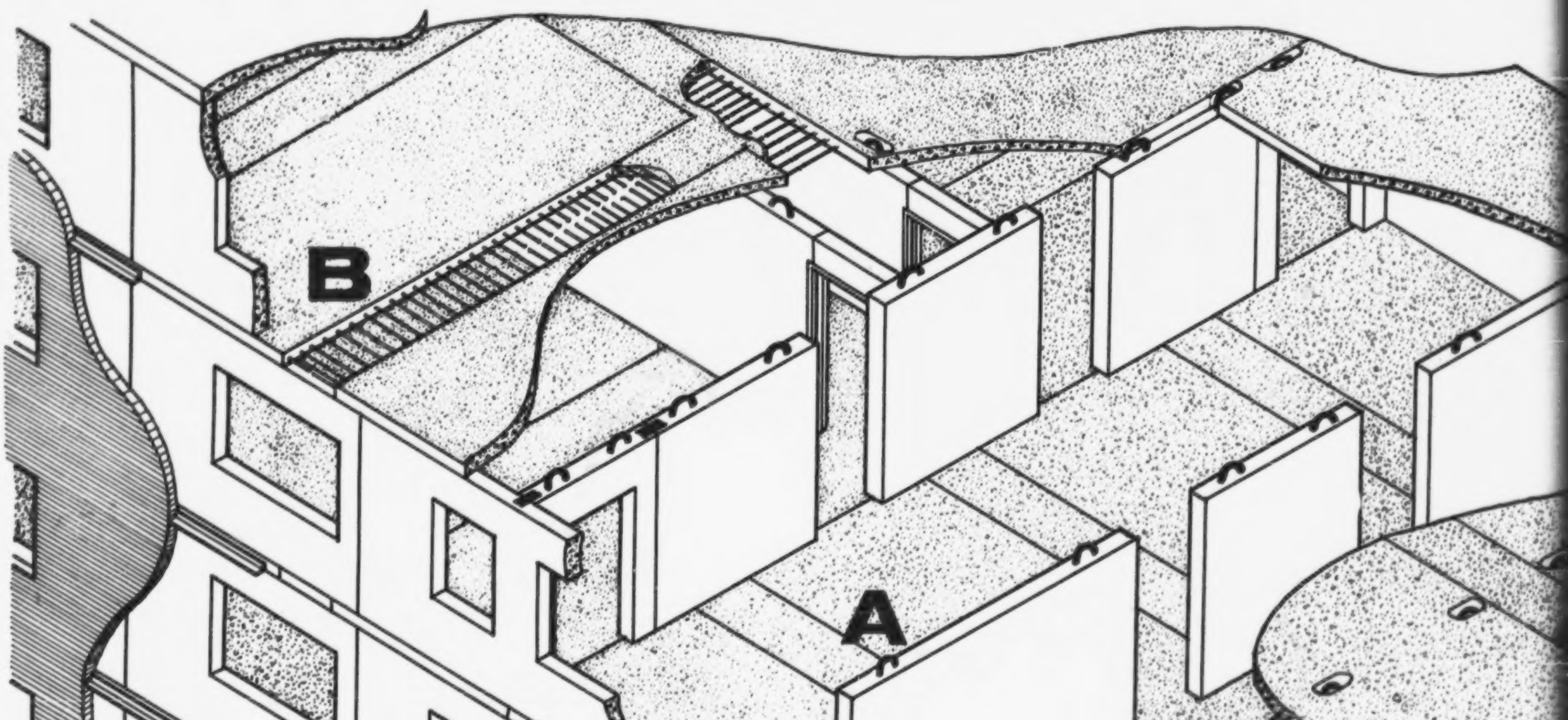
This section shows the application of a precast curtain wall enclosing the entire box-frame system. The panels are bolted to the floor slab top and bottom and a spline of insulation acts as the joining strip between the two panels themselves.

SECTION C

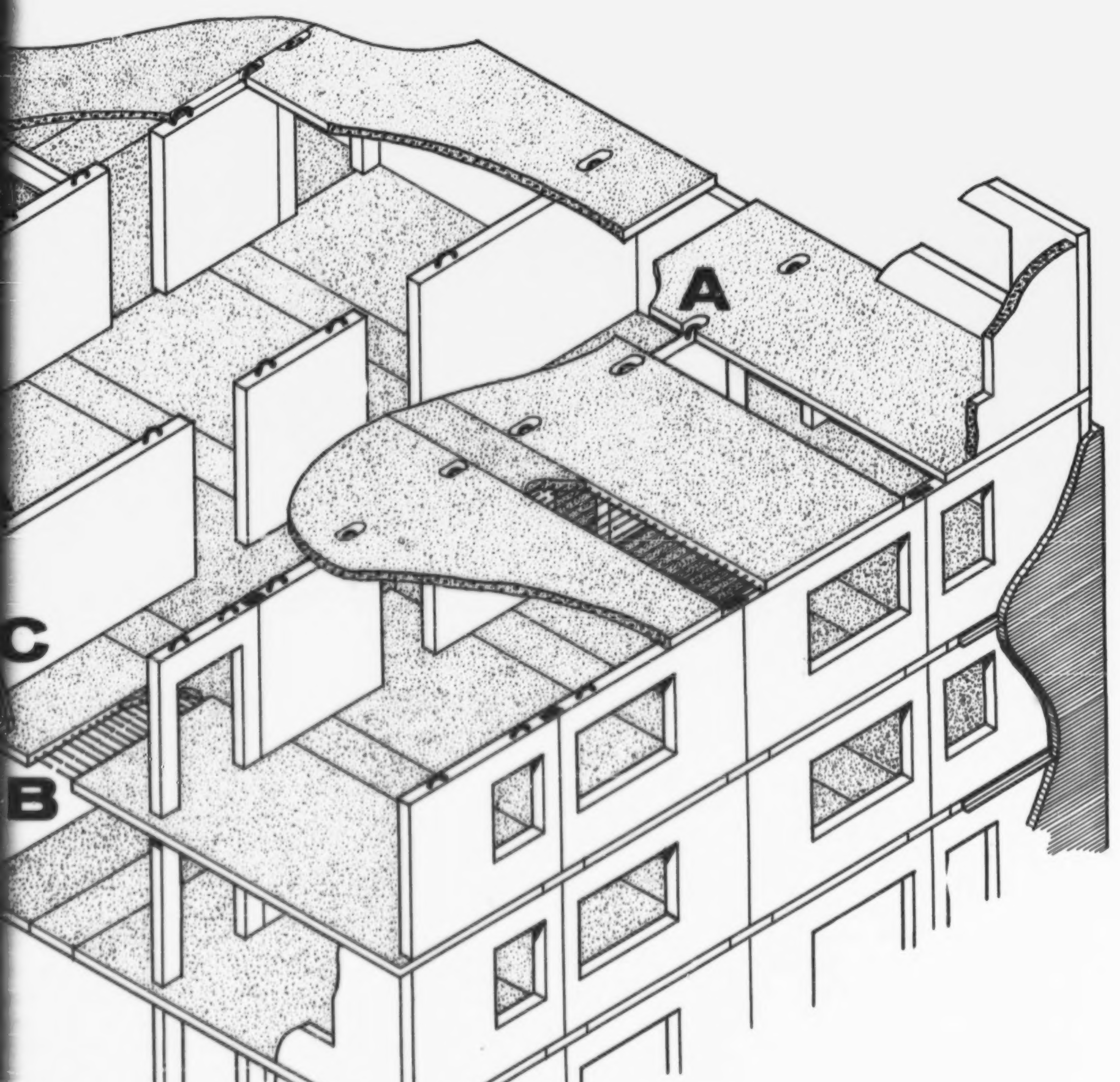
This section shows the exterior wall as load bearing but left exposed as part of the exterior treatment of the wall as illustrated on a previous elevation study. The solid precast panel is backed up by an inner wall of Insulrock to give the wall a better insulating value.

SECTION D

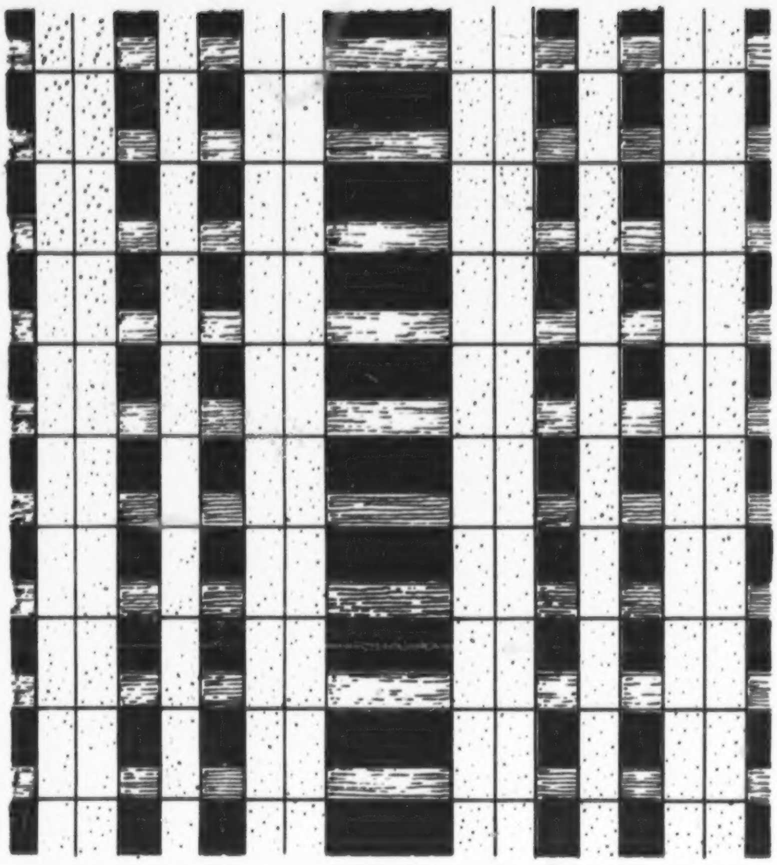
This section shows the exterior wall as a precast curtain panel applied within the cell or honeycomb of the box-frame structure. The curtain panel is shown as solid concrete rather than an insulated sandwich and is backed up by Insulrock.

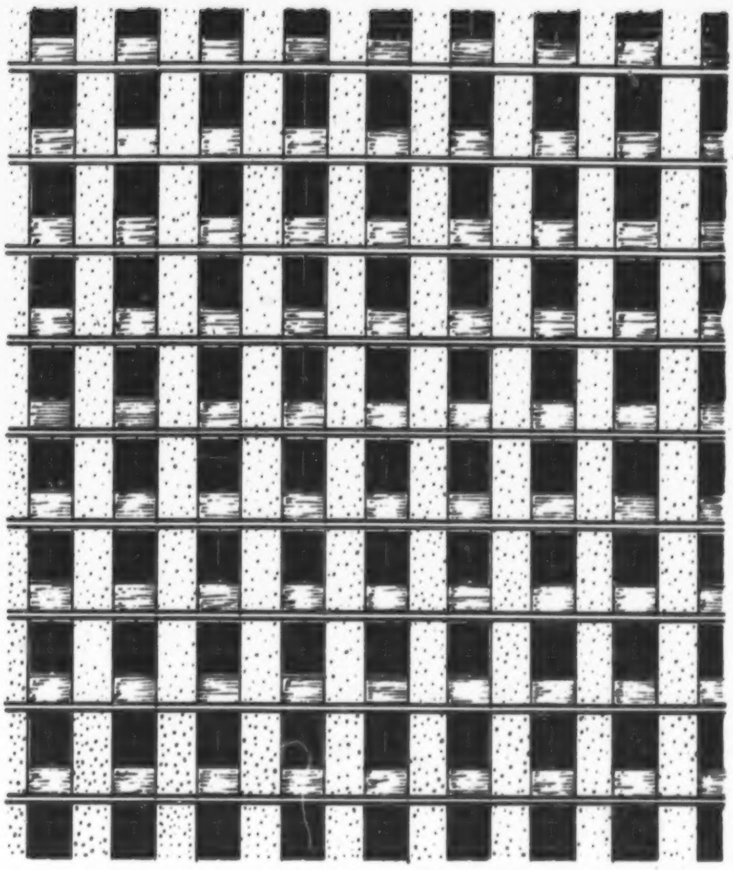


Isometric cut-away view of the current New York City housing project whose plan appeared on a previous page. This view shows the precast load-bearing walls and precast floor slabs in their relative positions. All other partitions have been omitted for the sake of clarity. The specific jointing techniques used between various type slabs and the position of these joints is also shown. A indicates lifting rings later grouted to anchor wall panels to floor panels. B indicates poured filler strip (note bars exposed in precast floor slab to permit strong bond between floor slabs). C indicates temporary shoring for free-standing wall slabs (kitchen walls in plan).



BOX-FRAME CONSTRUCTION





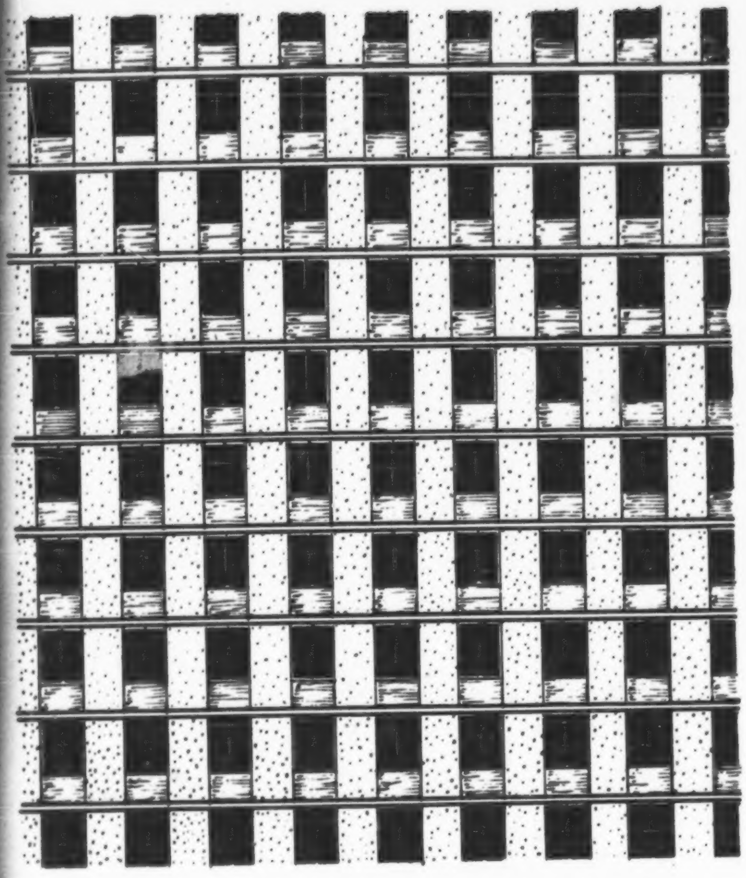
Study of Exterior Treatment

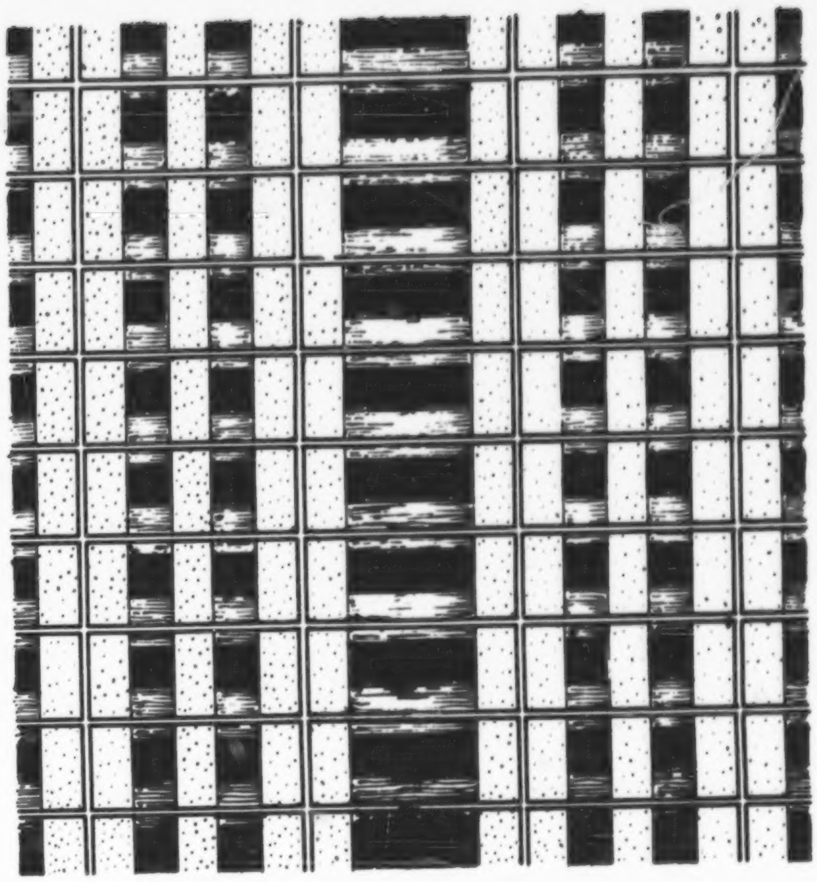
CURTAIN WALL

In this elevation development it has been assumed that the structural system has been designed as the ideal for box-frame in which the total structure forms a series of cellular boxes or honeycombs. As the first possible elevation treatment of such a structure, a curtain wall has been placed completely over the structure. The curtain wall itself would be formed of precast concrete sandwich panels designed on a strict modular basis according to the bay size of the structure behind. Spandrel panels could be of color integrated with the precast concrete. The panels would be simply clipped top and bottom to the precast floor panels and connected one to the other by standard details for such connections. The overall effect would be an expression of verticality achieved by the alternating bands of solid and window panels.

HORIZONTAL EXPRESSION

In this elevation, the floor slabs are carried beyond the exterior walls as one of the main architectural expressions. The structure behind can be the standard cellular box frame or, as an alternate structural solution, the solid panels shown could be the load bearing members placed on the perimeter of the building with light curtain panels as the fill in between the structural members. In this alternate structural scheme the structural members are clearly expressed because of the rigid grid required of alternating solids and voids in order to gain maximum support of the floor slabs above. In such a system a cross wall would occur every so often to act as a stiffener and wind brace. The overall expression of the floor slabs would aid greatly in reducing the scale of the building.





HORIZONTAL EXPRESSION

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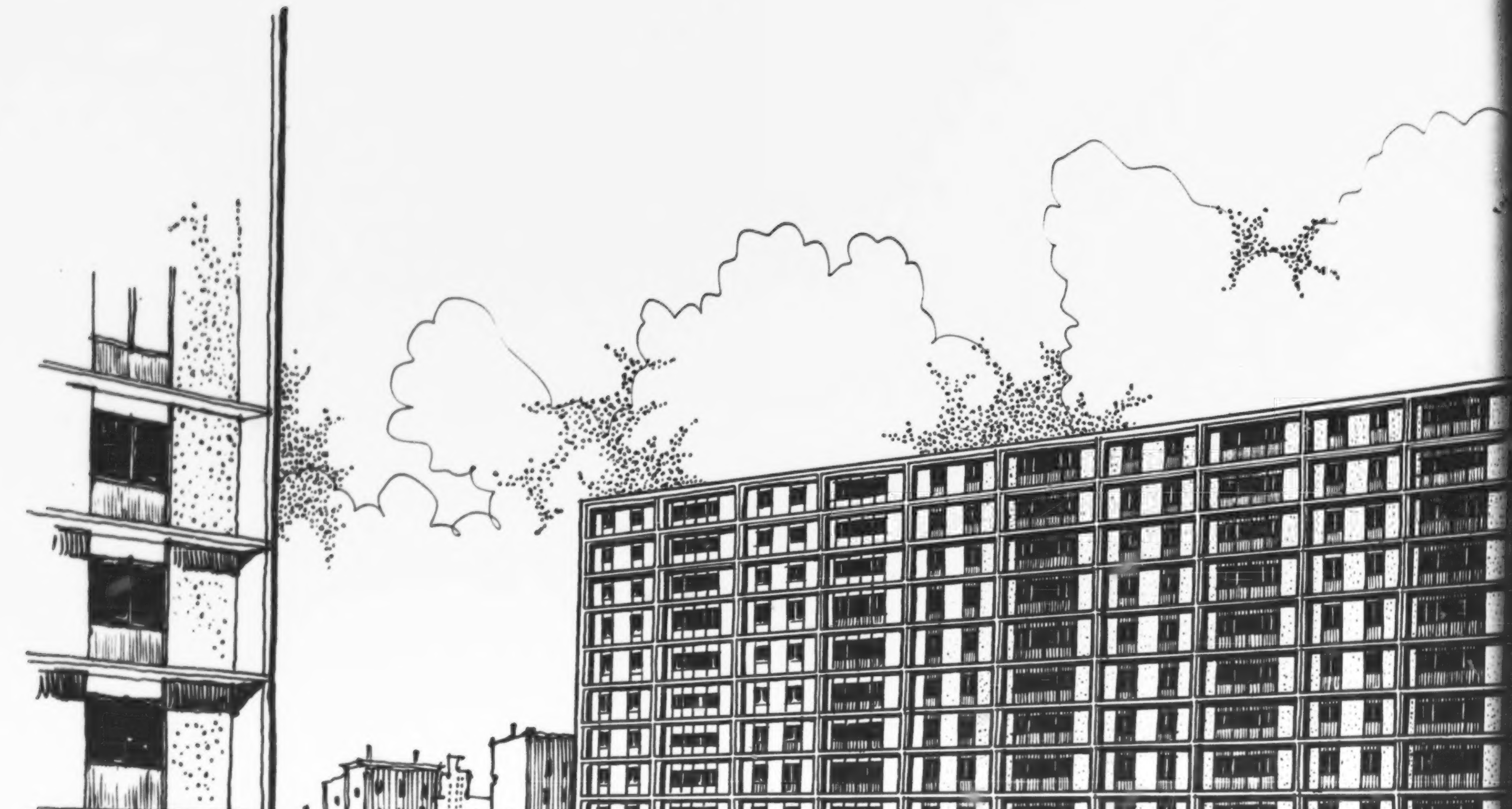
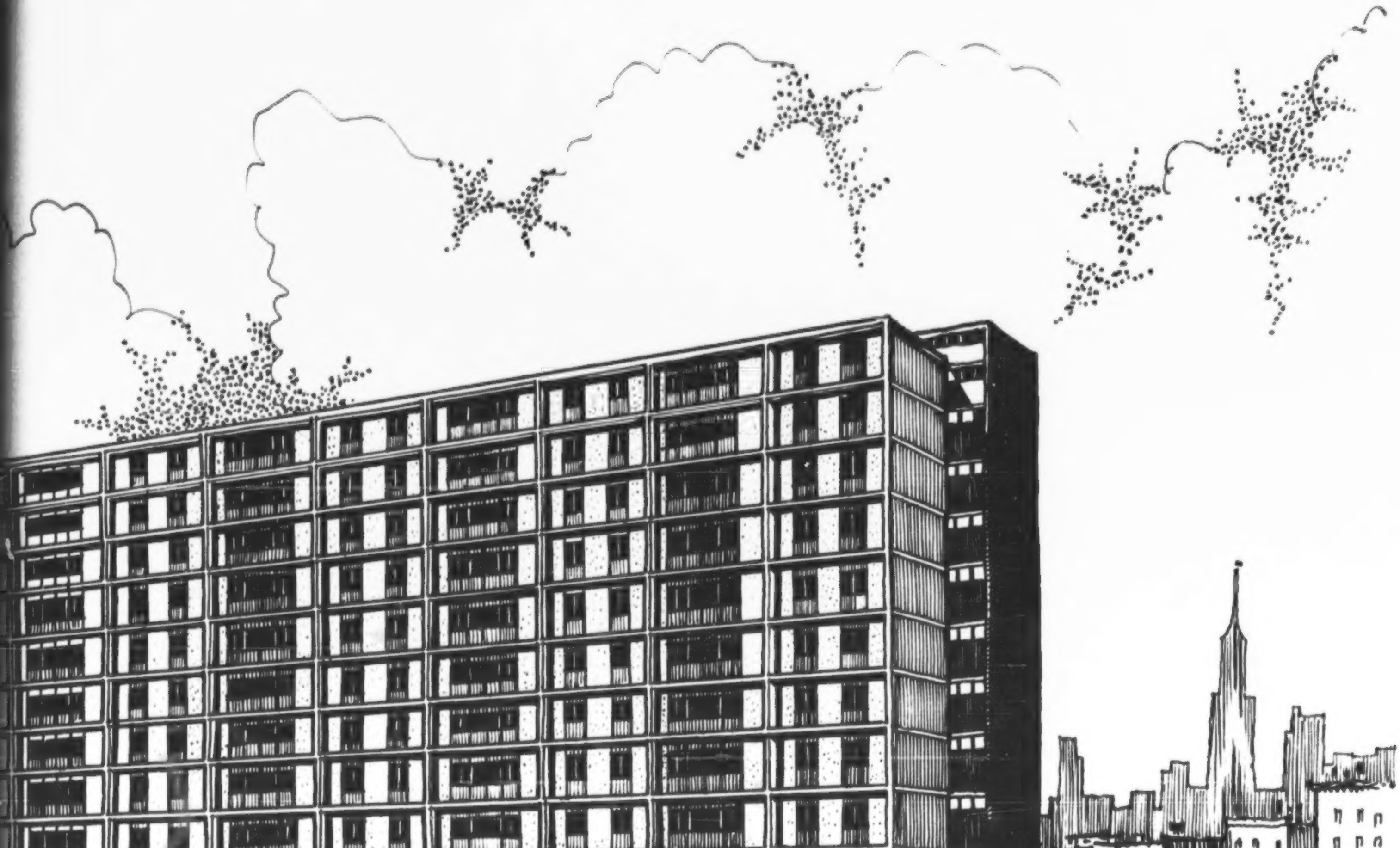
THE GRID

In this elevation development the entire structure is exposed and is the main architectural expression of the building. The cellular, honeycomb like character of the box frame is now clearly defined. Bearing walls and slabs are recognized for what they are and what they do. Within the structural grid the curtain panels can be expressed as solids, voids or combination of both for the main expression will always be the structure, the curtain being subservient to it. Here again the total scale of the building is further reduced for the grid now clearly defines rooms and combinations of rooms. The onlooker perhaps feels more comfortable in such a surrounding for instead of the overpowering effect of sheer wall masses surrounding him he can see this massing broken down into clearly articulated living spaces, as is evident in the rendering presented at the right.




R. Cordelier

BOX-FRAME CONSTRUCTION

4 LIGHT-STEEL FRAMING

There has been a considerable amount of controversial discussion about the potential use of light-steel framing in multi-story apartment house construction. It was decided by the research staff to analyze this method of structural framing. Throughout this analysis it has been exceptionally difficult to corroborate any factual data due to the wide fluctuation of conflicting professional opinion.

After extensive review, the stand taken by the research staff is that light-steel framing should definitely be considered as a possible structural method for low-income housing projects. There should be at least some consideration given to an alternate system of design and bidding where a true picture of the possible economic value of light steel framing could be seen. A project should not be designed for concrete and then offered for bid with steel as an alternate. The desired method would be to prepare a separate design in which the building would be planned for the limitations and requirements of light-steel framing.

One basic consideration is that of using a regular column spacing. This has been estimated to save from 5% to 10% of the structural cost, so it is actually a cost saving — not just a restrictive requirement. Another point that cannot be stressed too heavily is that the architect should be given some freedom in planning of apartment layouts so that the regular spacing, so necessary with steel construction, will not become a planning handicap. Some relaxation of the stringent room size requirements should result in an overall lower building cost.

Regular column spacing is not a unique requirement restricted just to light-steel framing. All structural systems are more economical if regular column spacing is used. Lift-slab, in particular, depends upon regular column spacing for major economies. One reason why regular column spacing achieves its 5% to 10% structural cost saving is due to the duplication of all steel members throughout the structure. Fabrication of all units becomes a simple problem as most parts are interchangeable. The steel obtains maximum usage of the theoretical moment which produces deflection in beams. Because of this maximum use of moments, there is no waste in the amount of steel required as there is in structural systems which contain unequal bay systems with scattered column spacing. Thus, the savings are also obtained in weight of steel required.

The use of light-steel framing is not a radical step in economical multi-story apartment house design. For many years it has been utilized to provide a rigid, fire resistant, economical floor construction for multi-story office buildings, schools, and apartment houses. An example of its use for apartment house construction in New York City is the forty-building Levitt Apartments in Whitestone, Queens. A cost comparison for this project will follow.

Some advantages of light-steel framing are as follows:

It is a fire-resistant construction.

Light in weight, thereby decreasing foundation loads as well as facilitating the handling and placing of members.

Goes up faster, and uses less field labor (particularly in forming) than most other structural systems.

Contractors take minimum risk in this kind of work, because almost all elements are prefabricated, not field manufactured.

Because of the open-web construction, space is available for the passage of pipes and electrical conduit. This will result in lower costs for the electrical and mechanical trades. It also will enable the running of unsightly steam risers and returns under floor to a central point.

Material is non-rotting and termite proof.

Standardized in dimensions and in carrying capacity.

With this introduction we present:

1. Comparative analysis of 8 structural systems — concrete slab floors with a variety of supporting beams and columns including steel joists framing equal bays.
2. Comparative cost analysis for Levitt Apartments — using the comparative structural analysis above to select a structural system for the forty-building Levitt Apartments in Queens.
3. Planning for steel framing —
   first, a review of the floor plan of a current New York City housing project and, second, a redesign of the concrete framing system of that housing project for light-steel framing; followed by an isometric of the proposed framing system and framing details.
4. Building code revisions — a review of the New York City Building Code with suggested revisions to permit greater use of light-steel framing.

Comparative Analysis of 8 Structural Systems

The following is a cost analysis of eight different structural systems for apartment houses. In this analysis light-steel framing (Scheme H) was found to be most economical. The analysis was originally undertaken by the firm of Holabird, Root and Burgee and published by the Gypsum Association. Since the cost figures for this comparison are not recent cost data, the cost figures were reduced to percentage form using Scheme H as 100%. For easy reference a tabular breakdown of the comparative analysis of the eight systems is presented first:

Scheme	Cost Factor
A	105%
B	151%
C	123%
D	151%
E	120%
F	119%
G	117%
H	100%

This is followed by a presentation of a typical framing plan and detailed section of each of the eight schemes:

A—2" concrete slab on steel joists, with steel beams and columns.

B—3" concrete slab, concrete joists, steel beams and columns.

C—3" concrete slab, concrete joists, concrete beams and columns.

D—4" concrete slab, steel beams and steel columns.

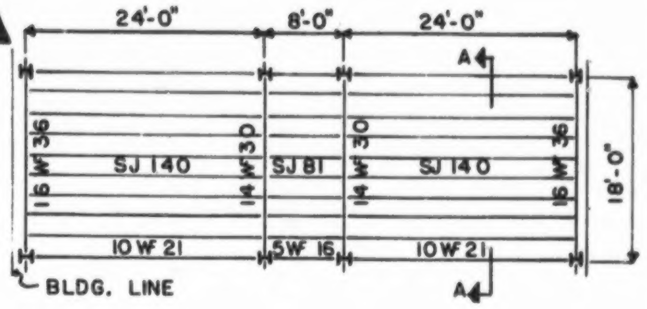
E—4" concrete slab, concrete beams and concrete columns.

F—4½" two-way concrete slab, wide band concrete beams and concrete columns.

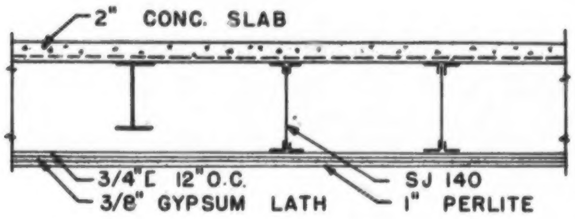
G—7½" concrete flat slab and concrete columns.

H—2" concrete slab on steel joists, steel beams and columns, equal bays.

A


24'-0"
8'-0"
24'-0"
A
16 WF 36
SJ 140
14 WF 30
SJ 81
14 WF 30
SJ 140
16 WF 36
18'-0"
10 WF 21
5WF 16
10 WF 21
BLDG. LINE
A

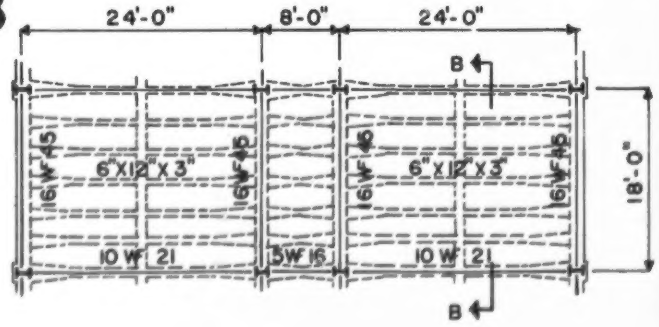
PLAN


2" CONC. SLAB
3/4" [12" O.C.
3/8" GYPSUM LATH
SJ 140
1" PERLITE

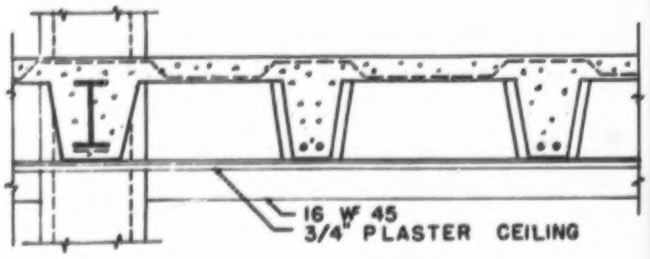
SECTION AA

2" stone concrete slab on hyrib or paper-backed lath on steel joists; steel beams and columns (fireproofed); 1" gypsum perlite ceiling.

B


24'-0"
8'-0"
24'-0"
B
16 WF 45
6"X12"X3"
16 WF 45
16 WF 45
6"X12"X3"
16 WF 45
18'-0"
10 WF 21
5WF 16
10 WF 21
B

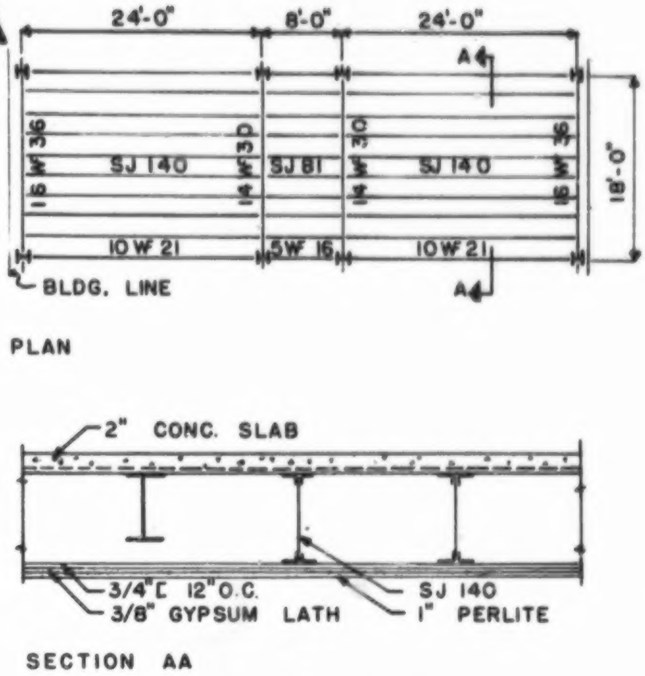
PLAN


16 WF 45
3/4" PLASTER CEILING

SECTION BB

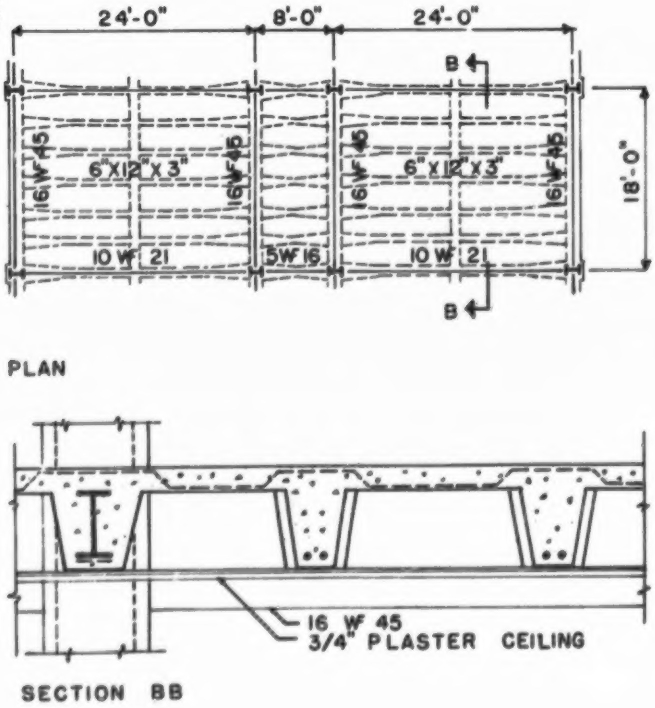
3" concrete slab on concrete joists; steel beams and columns (fireproofed); ¾" plaster ceiling on metal lath.

A


24'-0"
8'-0"
24'-0"
A
16 WF 36
SJ 140
14 WF 30
SJ 81
14 WF 30
SJ 140
16 WF 36
18'-0"
10 WF 21
5WF 16
10 WF 21
A
BLDG. LINE
PLAN
2" CONC. SLAB
3/4" [12" O.C.
3/8" GYPSUM LATH
SJ 140
1" PERLITE
SECTION AA

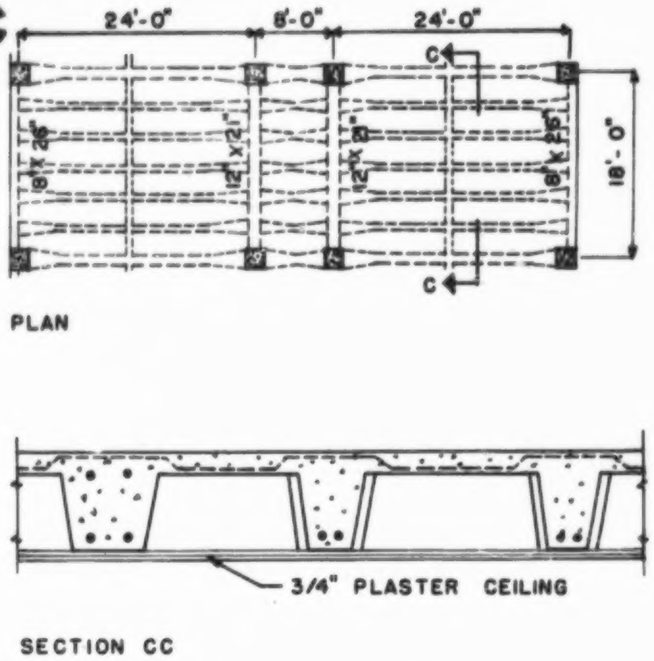
2″ stone concrete slab on hyrib or
paper-backed lath on steel joists;
steel beams and columns (fireproofed);
1″ gypsum perlite ceiling.

B


24'-0"
8'-0"
24'-0"
B
16 WF 45
6"X12"X3"
16 WF 45
16 WF 45
6"X12"X3"
16 WF 45
18'-0"
10 WF 21
5WF 16
10 WF 21
B
PLAN
16 WF 45
3/4" PLASTER CEILING
SECTION BB

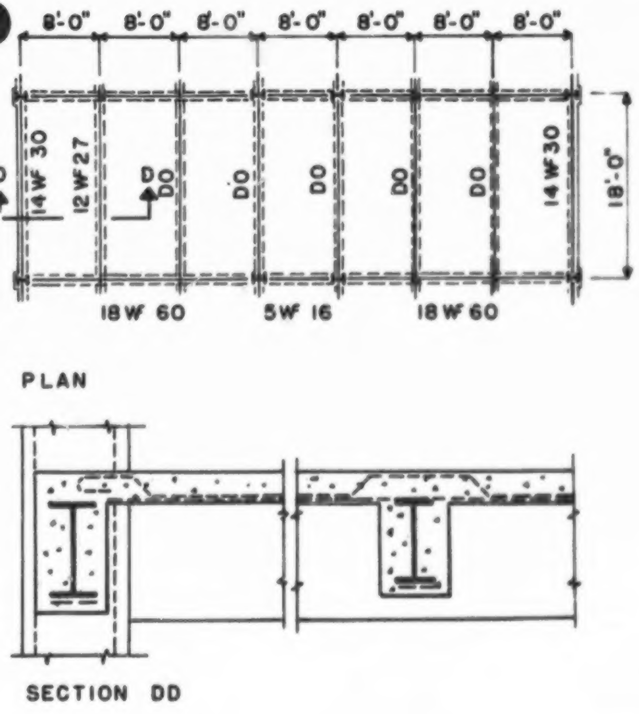
3″ concrete slab on concrete joists;
steel beams and columns (fireproofed);
¾″ plaster ceiling on metal lath.

C


24'-0"
8'-0"
24'-0"
C
18"x 26"
12"x 21"
12"x 21"
18"x 26"
18'-0"
C
PLAN
3/4" PLASTER CEILING
SECTION CC

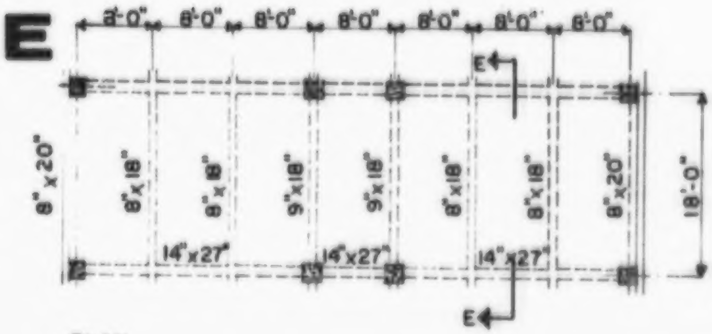
3″ concrete slab on concrete joists;
concrete beams and columns;
¾″ plaster ceiling on metal lath.

D

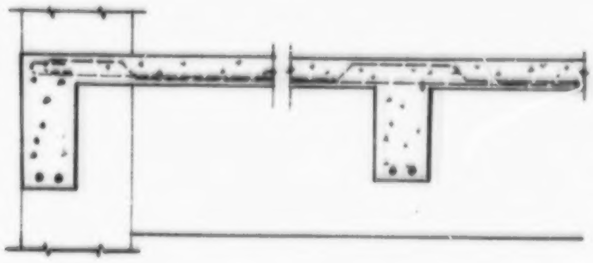

8'-0"
8'-0"
8'-0"
8'-0"
8'-0"
8'-0"
8'-0"
D
14 WF 30
12 WF 27
D
DO
DO
DO
DO
DO
14 WF 30
18'-0"
18 WF 60
5WF 16
18 WF 60
PLAN
SECTION DD

4″ concrete slab on steel beams;
steel beams and columns (fireproofed);
⅜″ bond plaster ceiling on slab.

E


2'-0"
8'-0"
8'-0"
8'-0"
8'-0"
8'-0"
8'-0"
E
8"x20"
8"x18"
8"x18"
9"x18"
9"x18"
8"x18"
8"x18"
8"x20"
18'-0"
14"x27"
14"x27"
14"x27"
E

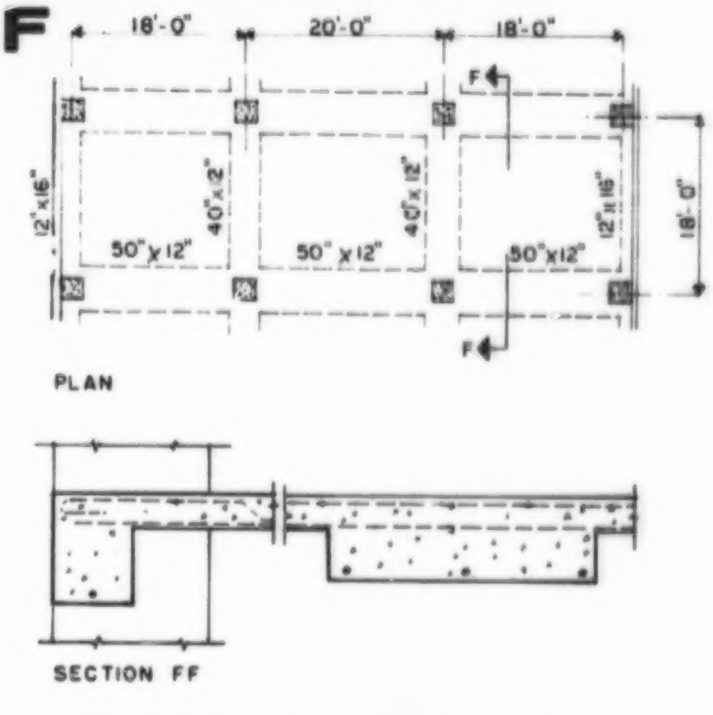
PLAN



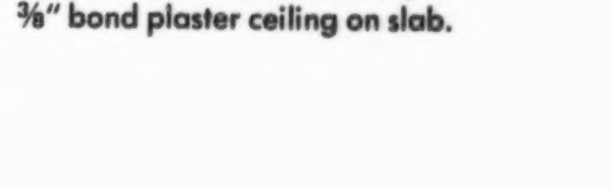
SECTION EE

4" concrete slab on concrete beams; concrete beams and columns; 3/8" bond plaster ceiling on slab.

F


18'-0"
20'-0"
18'-0"
F
12"x16"
40"x12"
40"x12"
12"x16"
50"x12"
50"x12"
50"x12"
18'-0"
F

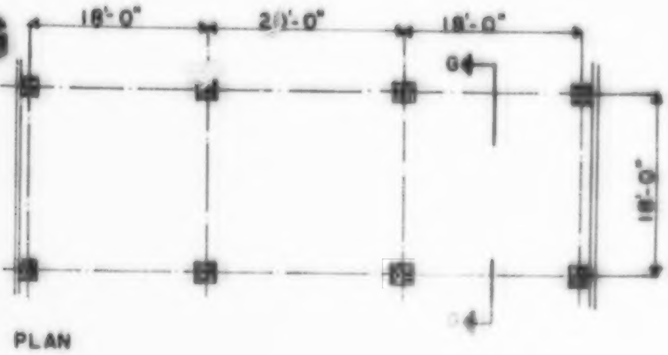
PLAN



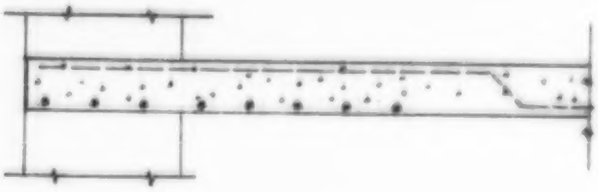
SECTION FF

4½" two-way concrete slab, wide band; concrete beams and columns; 3/8" bond plaster ceiling on slab.

G


18'-0"
20'-0"
18'-0"
G
18'-0"
G

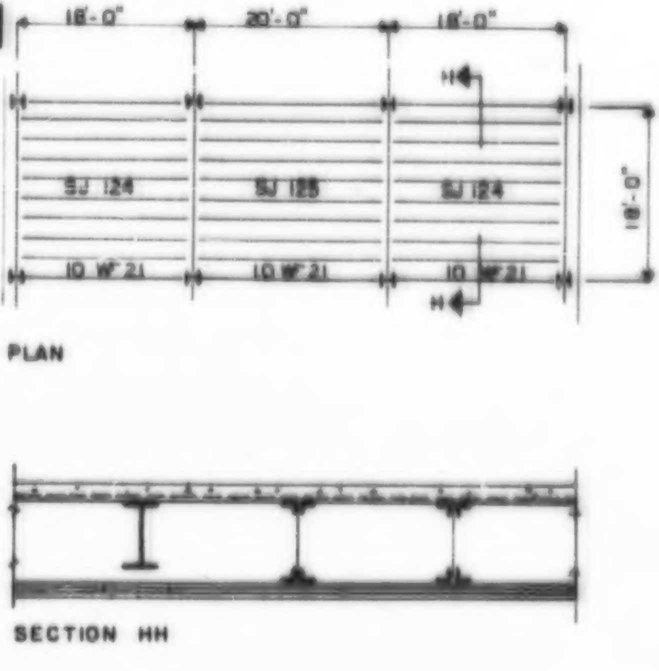
PLAN



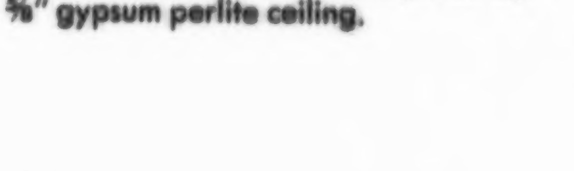
SECTION GG

7½" concrete slab, no beams; concrete columns; 3/8" bond plaster ceiling on slab.

H


18'-0"
20'-0"
18'-0"
H
SJ 124
SJ 125
SJ 124
18'-0"
10 W 21
10 W 21
10 W 21
H

PLAN



SECTION HH

2" concrete slab on steel joists; steel beams and columns (fireproofed); 5/8" gypsum perlite ceiling.

Comparative Cost Analysis for Levitt Apartments

The following is a cost analysis prepared by Edward Schnitzer; engineer, in June 1957, as a preliminary study for a group of New York City apartments. These results have been revised as of April 1958. Although the building size in this analysis is not identical with the plan reviewed and redesigned later, the building width, sizes of bays, and sizes of structural members are sufficiently close to give a realistic comparison.

The structural system consisted of an open panel skeleton of rolled solid web sections except for exposed columns below the first floor, which were fireproofed lally columns. Solid web joists were used as fill-in beams and a modified wind bracing connection devised at certain columns. All girders on the front and back of the building were cantilevered on a 1:3.68 ratio, enabling the facade loads and cantilevered area loads to be used as a counterweight to the interior floor loads and thereby achieving economy of steel in these girders.

The floor system consisted of a 2¼" reinforced concrete slab supported upon the steel framing. The top of the steel was set 2" below the top of concrete, thereby providing full lateral bracing effect to all beams and joists. The underside of the steel framing was tied together with rib lath and a ⅞" vermiculite plaster placed thereon, thus providing a 3-hour construction.

Following is the analysis of structural costs for the Levitt Apartments in Whitestone, Queens:

COSTS (STRUCTURAL) - LEVITT HOUSES

Cost Estimate for light-steel construction:

2¼" Concrete Slab	$0.55 SF
Steel (including cols.)— 7.9#/sq. ft. @ 17½c/#	1.38 SF
Field Paint Coat on Steel— 7.9#/sq. ft. @ 1c/#	0.08 SF
⅞" vermiculite plaster on rib lath	0.45 SF
Cost of light steel construction —...........	**$2.46 SF**

Cost Estimate for 6" Concrete Flat Slab Construction:

6" Concrete Slab— 0.5 cu. ft./sq. ft. @ 90c/cu. ft.	$0.45 SF
Column Concrete— 0.05 cu. ft./sq. ft. @ 90c/cu. ft.	0.05 SF
Reinforcing Steel— 4.37#/sq. ft. @ 22c/#	0.96 SF
Slab formwork— 1.00 sq. ft./sq. ft. @ 90c/sq. ft.	0.90 SF
Col. formwork— 0.15 sq. ft./sq. ft. @ 72c/sq. ft.	0.11 SF
Rubbing Concrete	0.19 SF
Finish (1" slick)	0.10 SF
Cost of 6" Flat Slab Construction —........	**$2.76 SF**

Comparison - Light-Steel and Concrete:

Light-Steel	$2.46 per sq. ft.
Add for increased height of building (7" per floor) 0.032 sq. ft. of wall per sq. ft. of floor area 0.032 x $1.25	0.04 per sq. ft.
Adjusted cost —	$2.50 per sq. ft.
6" Concrete Slab	$2.76 per sq. ft.
Add for increased cost of foundation and excavation due to greater weight of structure —	.03 per sq. ft.
Adjusted Cost —	$2.79 per sq. ft.

Recapitulation:-

6" Concrete	**$2.79**
Light-Steel	**2.50**
	$0.29 per sq. ft. of floor area

Since this analysis was made (June, 1957) there has been a considerable drop in the price of structural steel and as of April 1958 the difference in cost had increased to **$0.76** per square foot of floor area.

Planning for Steel Framing

The next portion of this study covers the review and redesign of a current multi-story New York City housing project. The actual project is to be constructed of flat plate reinforced concrete, but here, for theoretical purposes only, it has been redesigned to utilize steel framing. Again it must be mentioned that an ideal plan cannot be arrived at by simply superimposing a regular steel grid over an existing concrete design.

The presentation consists of framing plans and details to clarify possible areas of cost savings. The various possible methods of framing in light steel are also shown: e.g. open-web joists, Stran-Steel joists, and Cofar type construction.

This portion ends with a full page isometric of the suggested light-steel framing system.

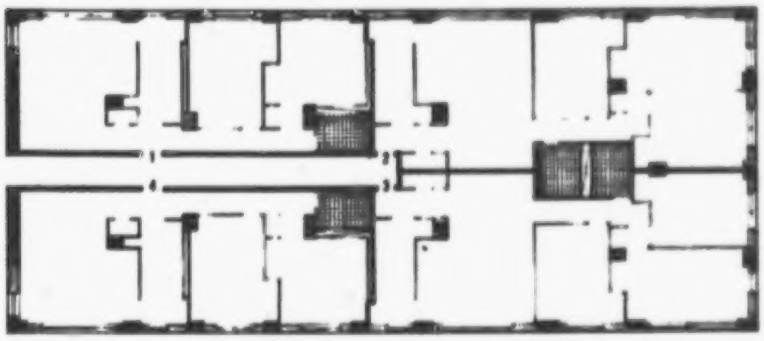
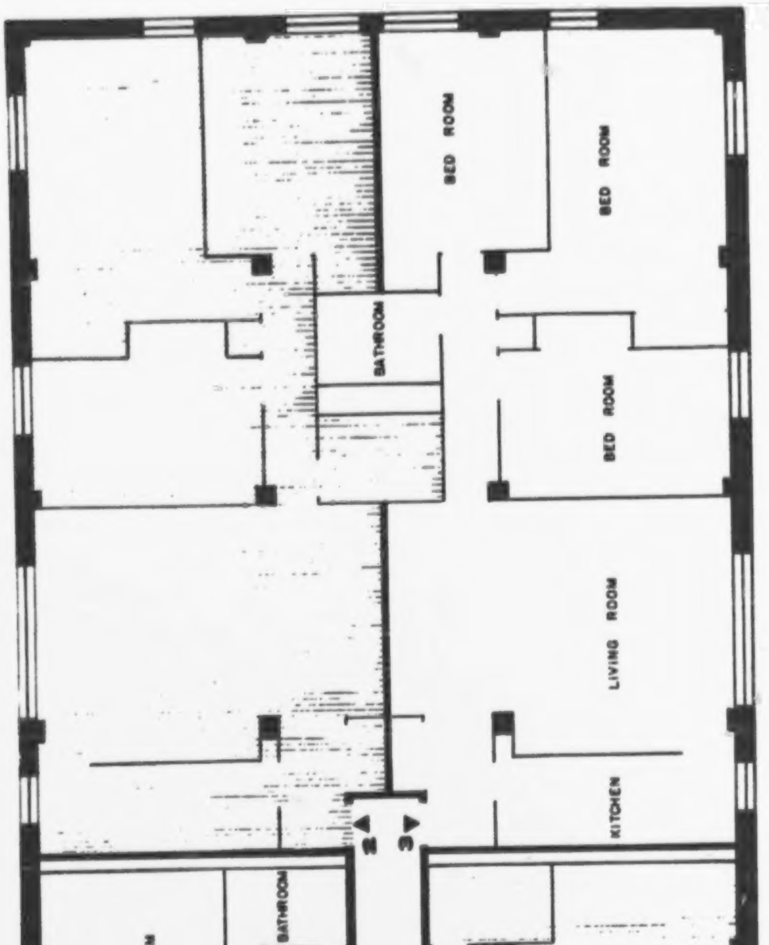


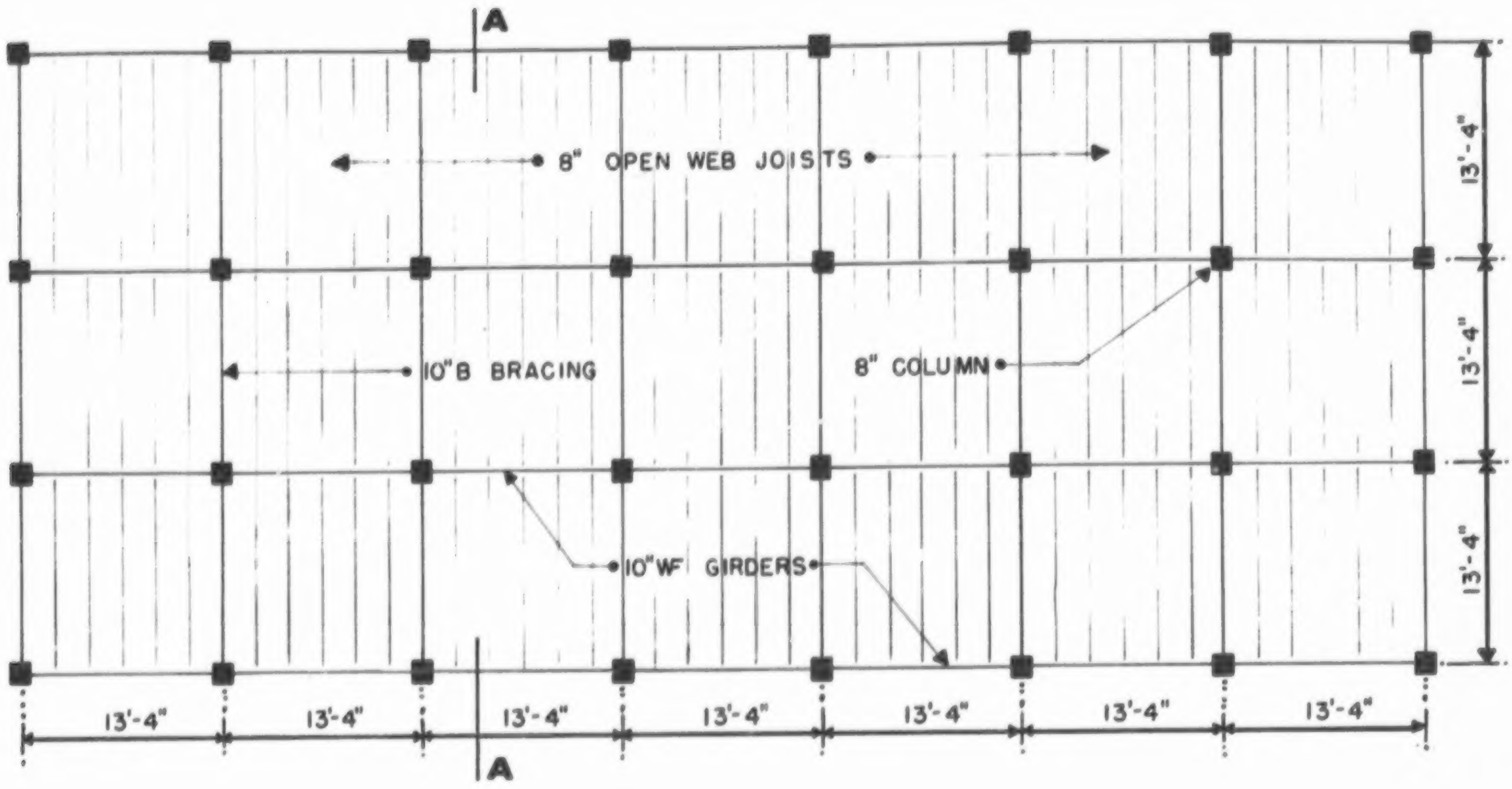
Diagram above indicates the floor plan of a current New York City housing project. The redesigned plan shows the application of light steel framing requirements to the existing plan. An equal-bay column grid has been superimposed over the existing scattered column plan. Certain partition changes had to take place in order to fit within this grid. With these changes certain room areas have been revised. This, however, is not the ideal way to design for steel. Ideally the most economical, equal-bay spacing should be analyzed and its structural grid outlined as the starting point for designed layouts. Architects should then work within this grid. They should not be required to work, as they are at present, within the much too stringent room size standards selected for such projects. Increases in area of certain rooms would prove more economical in the long run because of the use of this ideal bay system. Better living areas would be realized at a reduction in the total cost of the project.

REDESIGN OF PLAN SHOWN AT LEFT
FOR LIGHT-STEEL FRAMING SYSTEM

IGN OF PLAN SHOWN AT LEFT
IGHT-STEEL FRAMING SYSTEM

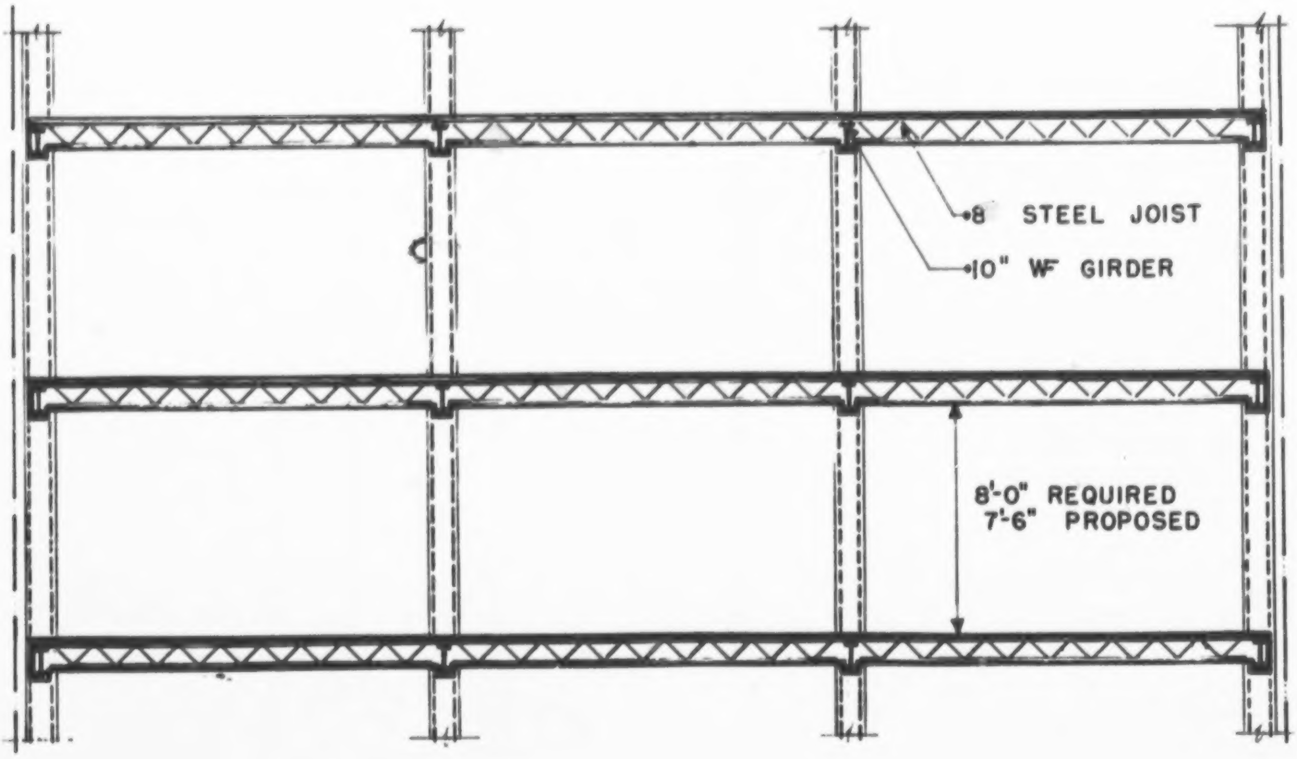

BED ROOM
BED ROOM
BATHROOM
BED ROOM
LIVING ROOM
KITCHEN
2
3
BATHROOM
BED ROOM
BED ROOM
KITCHEN
PUBLIC HALL
1
4
LIVING ROOM

LIGHT-STEEL FRAMING

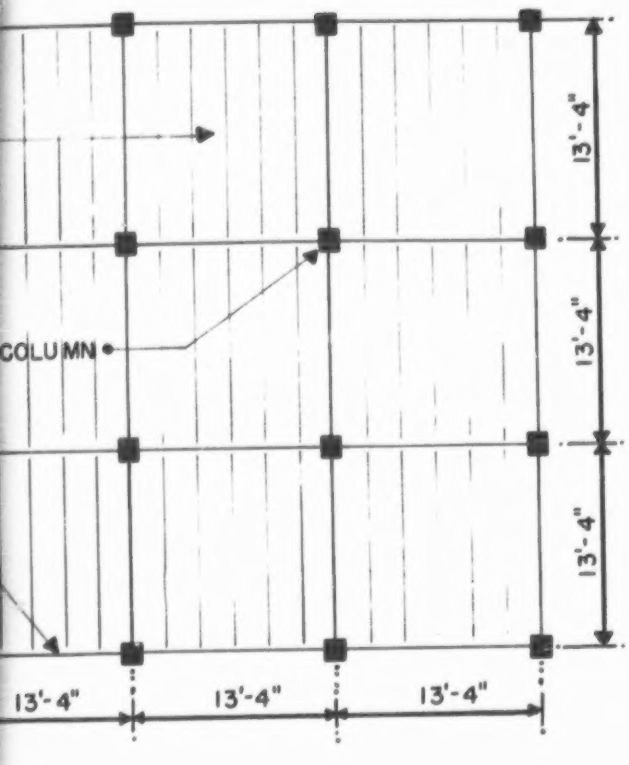

A
8" OPEN WEB JOISTS
10"B BRACING
8" COLUMN
10"WF GIRDERS
13'-4"
13'-4"
13'-4"
13'-4"
13'-4"
13'-4"
13'-4"
13'-4"
13'-4"
13'-4"
A

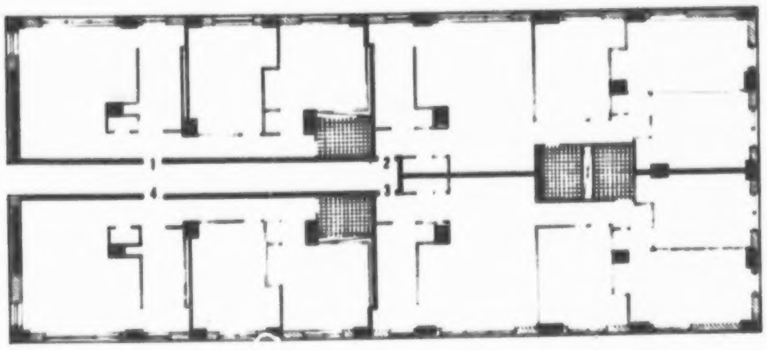
FRAMING PLAN

SECTION A-A


8 STEEL JOIST
10" WF GIRDER
8'-0" REQUIRED
7'-6" PROPOSED

LIGHT-STEEL FRAMING





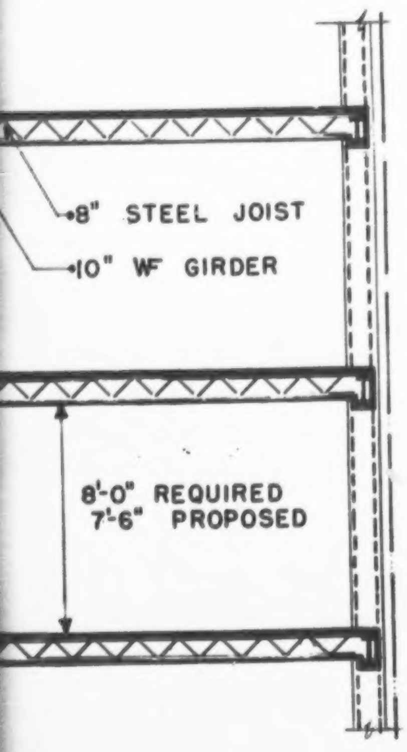
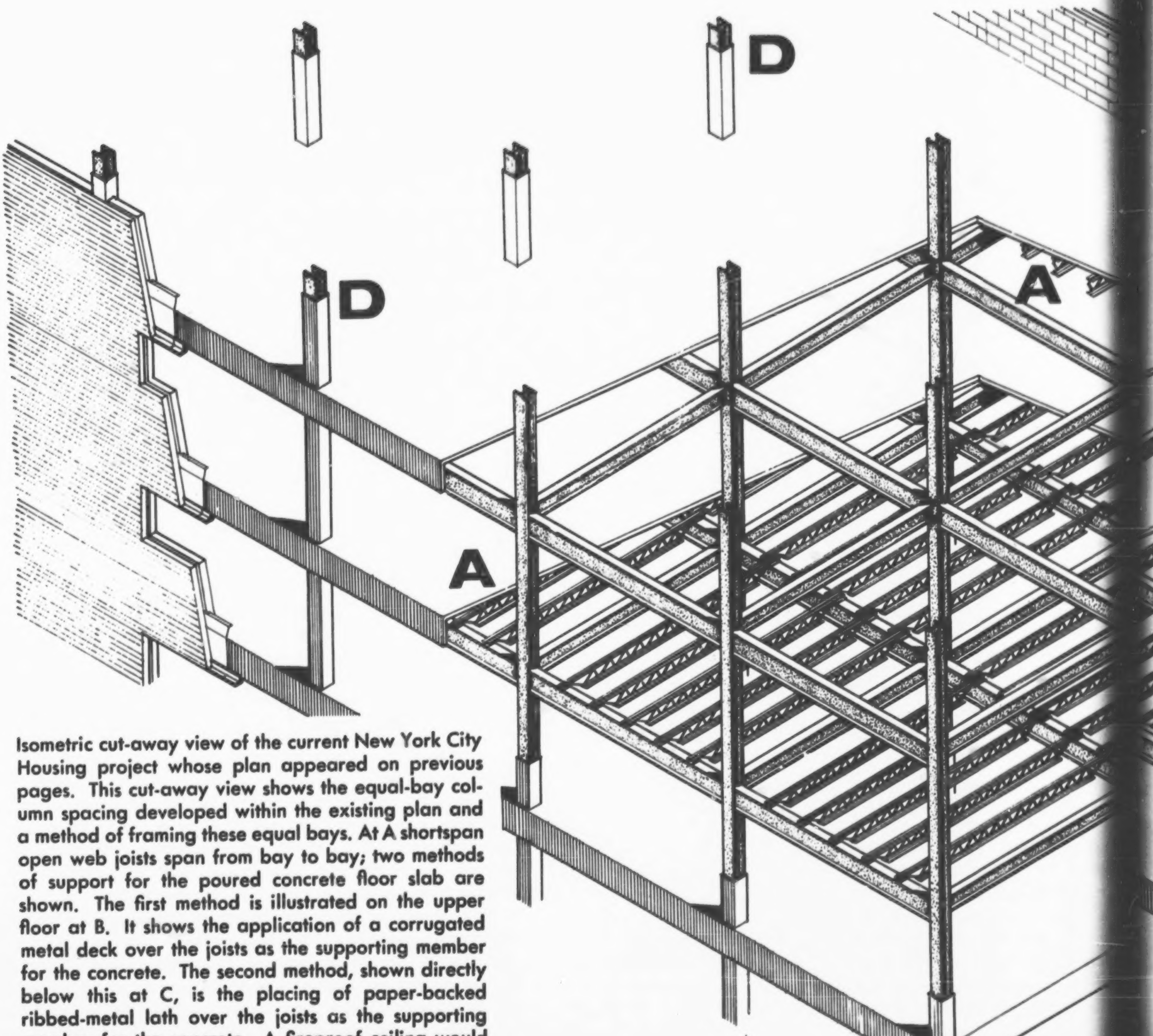


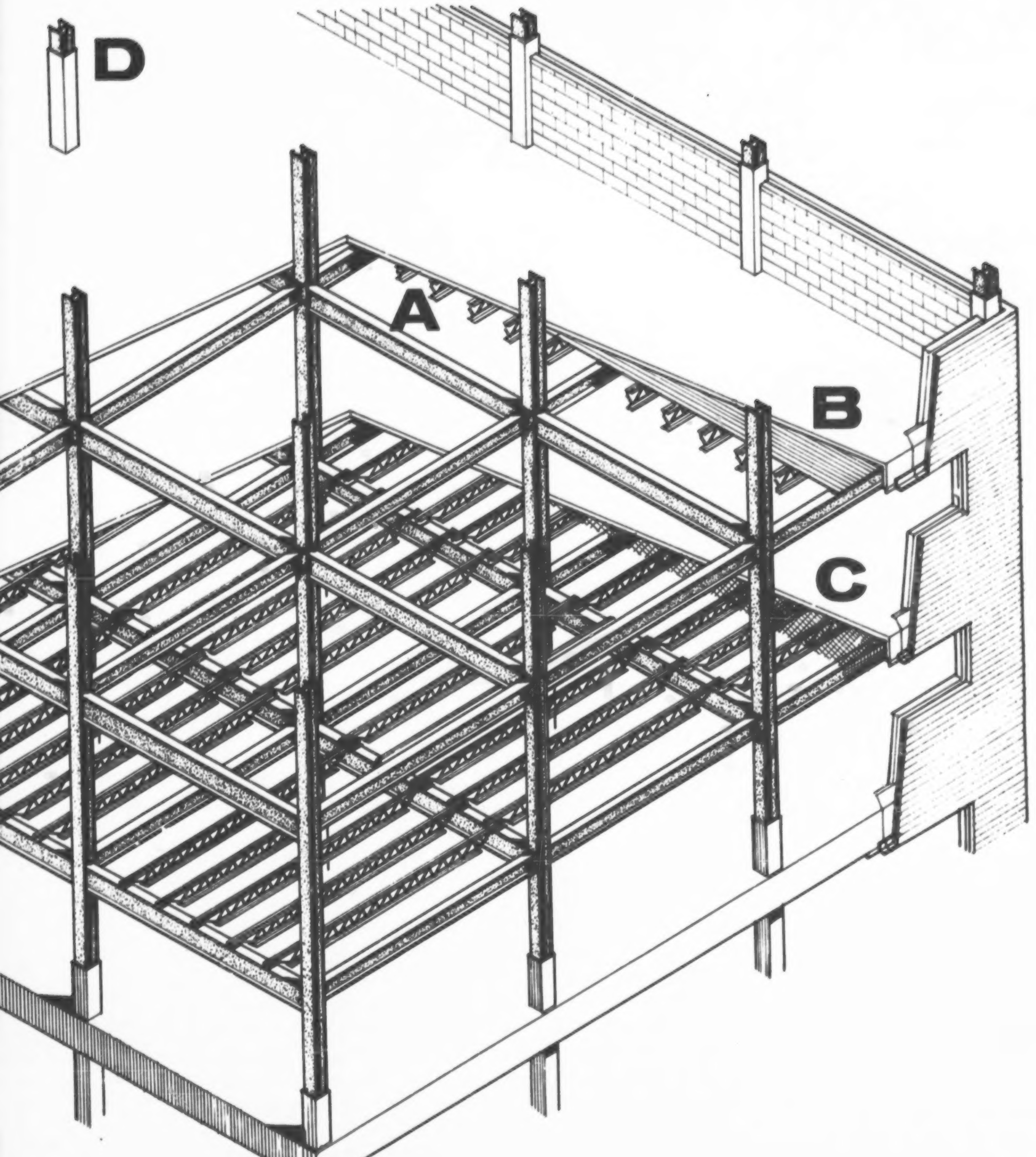
Diagram above shows the concrete framing system of a current New York City housing project. Notice the irregularity of the spacing and the variety of size of the columns as compared to the redesigned plan.

Illustrated is the equal-bay framing system developed within the same architectural floor plan of the current project. As was mentioned, this is not necessarily the ideal or most economical bay type to be developed; but it suffices to show how well the framing can be simplified and a duplication of parts of standard size brought about. The equal-bay spacing illustrated shows the columns on a 13'-6" center line spacing. Within each bay the short span open web joists are placed 2'-3" on center, 5 joists per bay. The steel members running parallel to the steel joists are utilized as intermediate bracing members.

The cross section taken through two typical floors, shows the joists carried by the main structural steel beams. On top of the joists is a 2½" poured concrete floor deck. Below the joists and around the main structural steel fireproofing would be placed to give the required 3-hour rating to the structure.

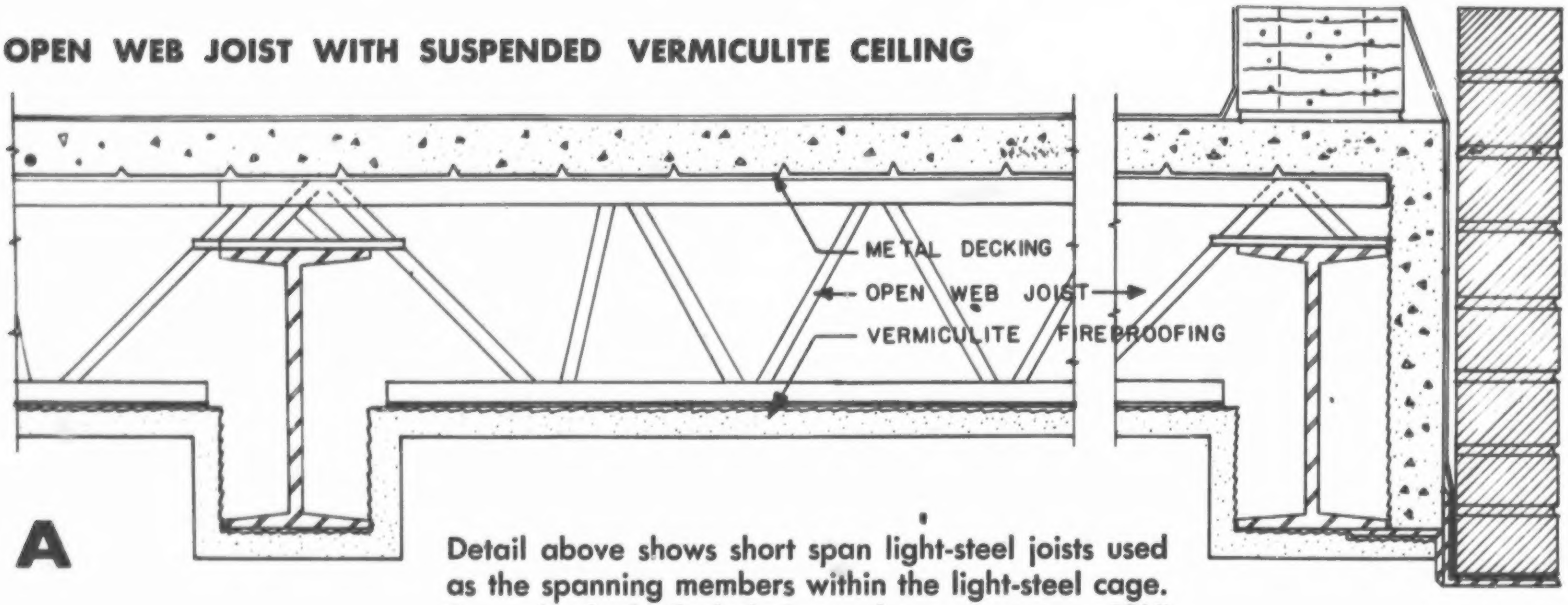


Isometric cut-away view of the current New York City Housing project whose plan appeared on previous pages. This cut-away view shows the equal-bay column spacing developed within the existing plan and a method of framing these equal bays. At A shortspan open web joists span from bay to bay; two methods of support for the poured concrete floor slab are shown. The first method is illustrated on the upper floor at B. It shows the application of a corrugated metal deck over the joists as the supporting member for the concrete. The second method, shown directly below this at C, is the placing of paper-backed ribbed-metal lath over the joists as the supporting member for the concrete. A fireproof ceiling would be applied below the joists to give the necessary fire rating. The fireproofing of columns and beams is illustrated at D.



LIGHT-STEEL FRAMING

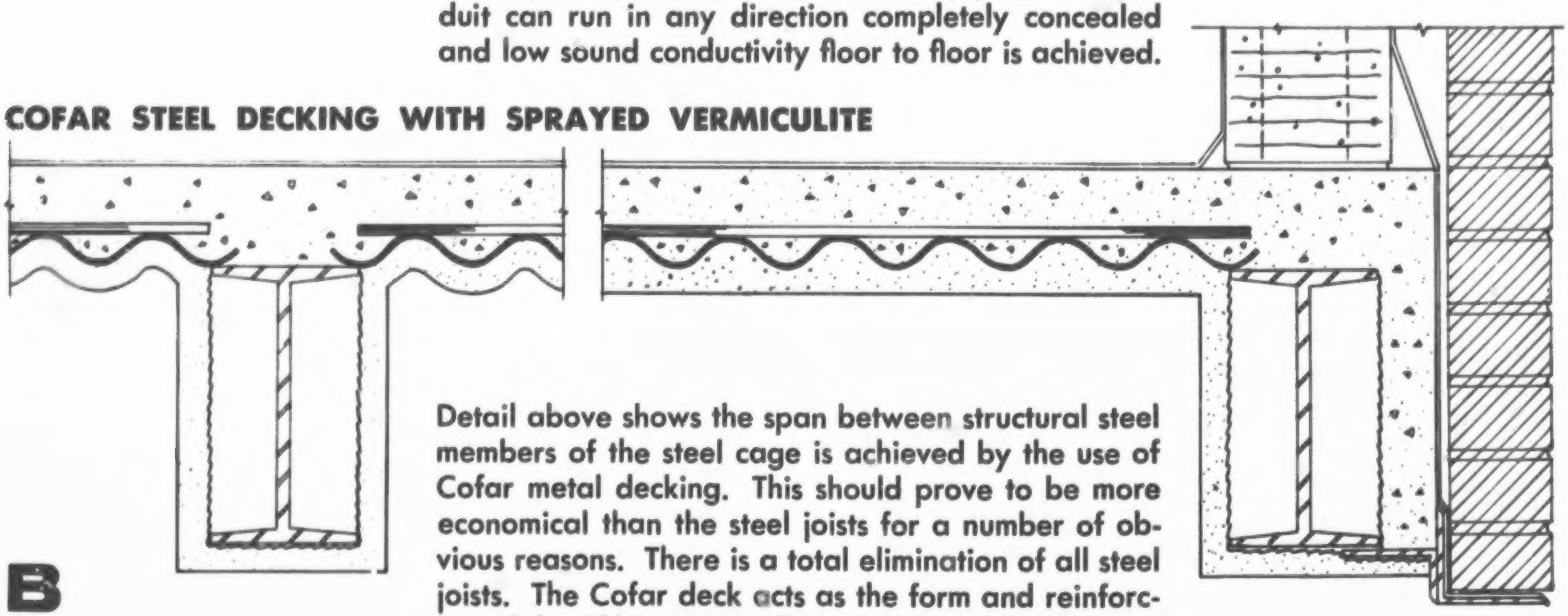
OPEN WEB JOIST WITH SUSPENDED VERMICULITE CEILING



A

Detail above shows short span light-steel joists used as the spanning members within the light-steel cage. Paper-backed rib lath is used to support a 2½" poured concrete floor deck. A 3-hour fire rating is achieved by covering all steel with ⅞" vermiculite. A few advantages of this system, easily seen above, are that no forming or shoring is required, size and weight of steel members makes for easy handling thereby increasing speed of erection, piping and conduit can run in any direction completely concealed and low sound conductivity floor to floor is achieved.

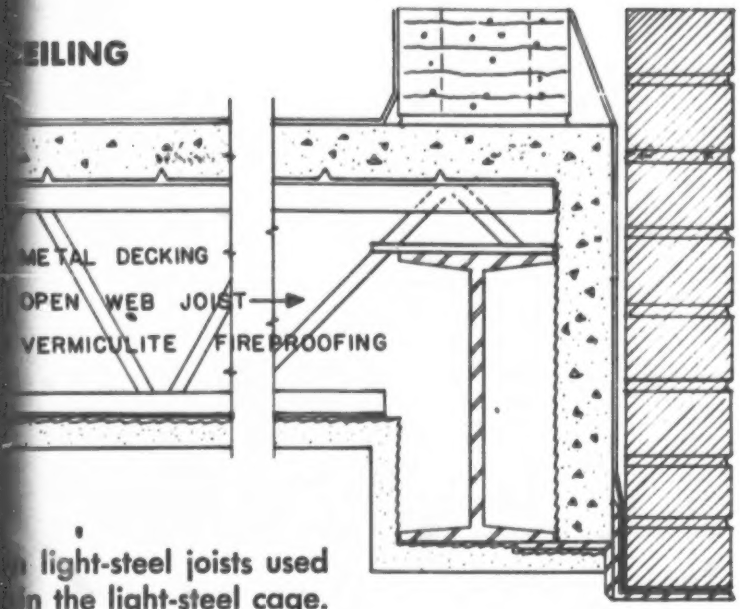
COFAR STEEL DECKING WITH SPRAYED VERMICULITE



B

Detail above shows the span between structural steel members of the steel cage is achieved by the use of Cofar metal decking. This should prove to be more economical than the steel joists for a number of obvious reasons. There is a total elimination of all steel joists. The Cofar deck acts as the form and reinforcing of the 2½" concrete floor deck. Fireproofing can be applied directly to the metal surface, eliminating most of the metal lathing required on the steel joists. Fireproofing could either be applied as a flat ceiling or gunited onto the Cofar, following the convolutions of the decking.

EILING



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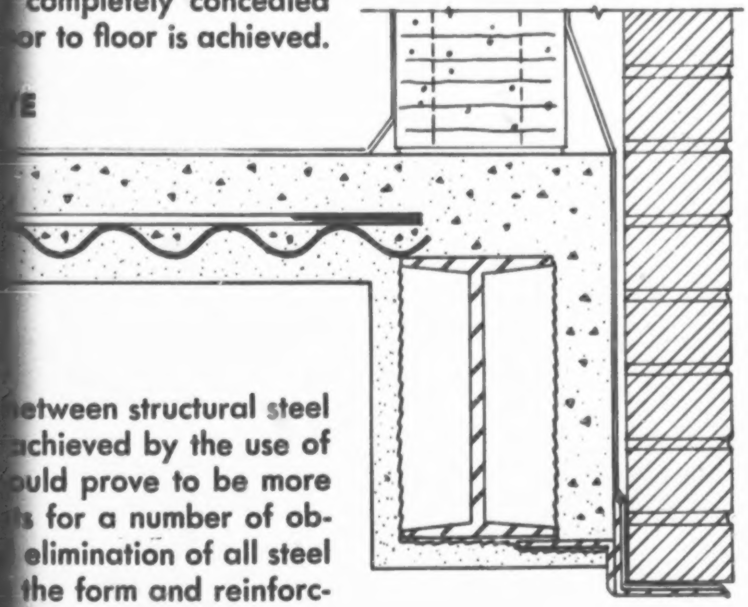
or to floor is achieved.

E



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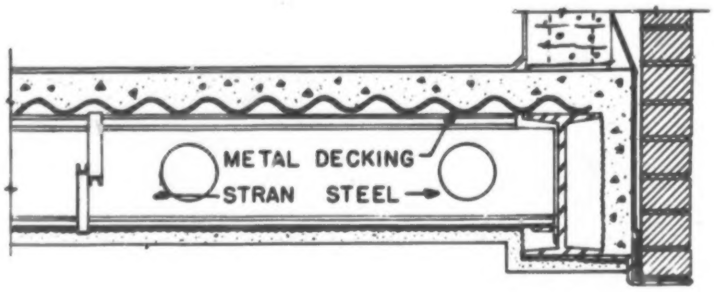
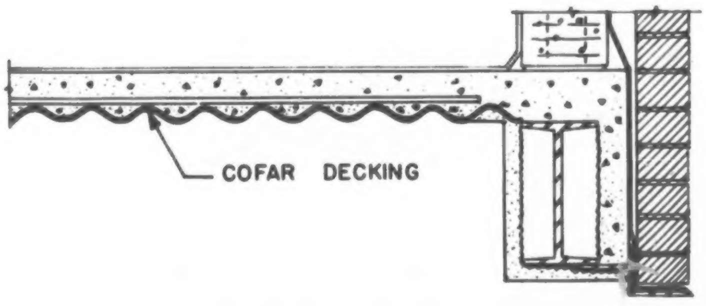


1

In this detail Stran-Steel members have been substituted for the short span joists. Stran-Steel is offered as a competitor of the open web joist and at any bidding time it should be considered as the alternate of the joist, depending on the prevailing prices between the two at the time.



2

This detail shows the Cofar decking exposed without the required fireproofing. Such a system would require a revision of the code. This revision will be clearly defined on a later sheet. It can be clearly understood that this system would be by far the most economical of the group for it completely eliminates the cost of fireproofing the decking.

Building Code Revisions

Throughout this report frequent mention is made of the potential savings that may be achieved by revising existing Building Code requirements. These comments have been made by so many architects, engineers, technical consultants, and manufacturers that it would be impossible to list them all in this report. Their suggestions have ranged from complete code overhauling to specific changes. A few of the suggested revisions that would help decrease construction costs, in steel construction in particular, are elaborated upon on this page.

In considering these proposed code revisions, it must be remembered that the research staff does not propose to increase the fire hazard or otherwise endanger in any way the future inhabitants of any proposed building. The premise that is proposed here is that the Building Code should be revised so that it will no longer prohibit safe economical construction. If the revision is made, it will result in economy of construction achieved by bringing the criteria of the code in line with present day construction standards and conforming to new knowledge of fire cause and protection.

Uniform Code Requirements:

Many present requirements are based on presumption and incorrect data. A careful analysis will show that New York City has an unnecessarily stricter code than most other cities. One obvious example is the required fire rating for a floor of a building unlimited in height. In New York City's code, the required rating is 3 hours, while most other codes require a 2 hour rating.

In order to eliminate conflicts similar to that just mentioned, it seems advisable to compare the following standard codes:

1. National Building Code recommended by the National Board of Fire Underwriters.
2. Uniform Building Code of the Pacific Coast Building Officials Conference.
3. The Southern Standard Building Code of the Southern Building Code Congress.
4. The basic code of the Building Officials Conference of America.

The result of this comparison should be the preparation of a modern set of fire regulations which will provide a degree of fire protection consonant with public safety and the fire hazards involved.

Fire-resistance based on burn-out and type of occupancy:

Before rational fire protection requirements could be formulated, it was obvious that a study had to be made to determine the nature and severity of fire hazards that exist in the various occupancies for which buildings are used. An analysis of this type was conducted by the National Bureau of Standards and has been published in the report "BMS-94 An Analysis of Fire Resistivity based on Burn-out and Type of Occupancy." The New York City Building Code should be examined to see where this information could be utilized to achieve economies. With our present knowledge of fire-fighting and fire-prevention, it certainly seems that many new housing projects are greatly over-designed in terms of fire protection. If the information as presented in BMS-94 will help reduce this over-design and still offer safety, it certainly should be utilized. It is felt by the research staff that acceptance of this theory and the resulting revision of the code would give a much more realistic approach to fire-rating requirements.

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Exposed Steel Decking:

One possible result of the acceptance of reduced fire ratings would be to permit the use of exposed steel decking. At present, expensive fireproofing is required under this deck in order to achieve the required fire rating. If this fireproofing could be eliminated and if all structural as well as mechanical details were carefully studied, a desired economy without any unsightly conditions would result. Before acceptance or rejection of this proposal is made a great deal more study should be given to it.

Elimination of restriction on height of light steel construction:

At present, the New York City code limits the use of light steel joist construction to buildings with a maximum height of 100'-0". From all examination, this appears to be based upon an arbitrary decision and not on fact. This method of construction has been satisfactorily used on many multi-story buildings, in other cities, higher than 100'-0". Since the use of light steel joists may lead to large cost savings, this arbitrary height limitation, that would reduce the potential savings, should certainly be eliminated.

Welding:

Since the welding section of the Building Code was written, welding has become more of a science than an art. Buildings, in which welding is efficiently utilized, can achieve savings in steel of approximately 15% to 20% if the steel is designed using the theory of continuity. At present this is not permitted by the New York City code. Due to the possible savings involved, serious consideration of this suggestion is recommended.

Conclusion:

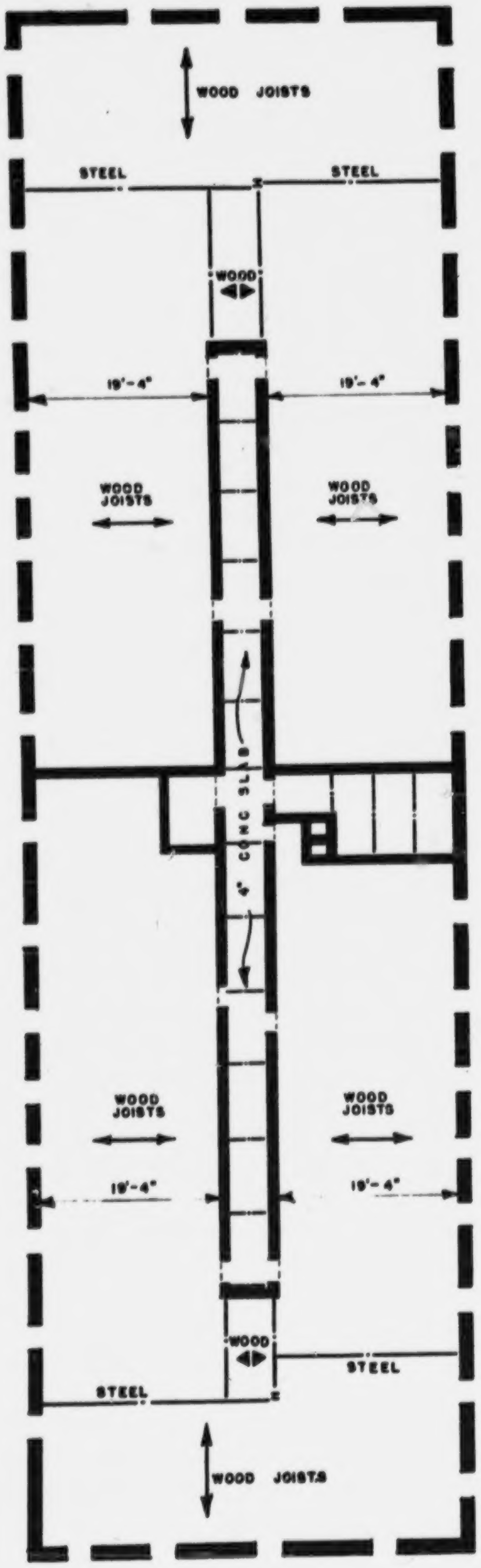
It is recommended that the New York State Division of Housing become instrumental in making suggestions for Building Code revisions and in working toward those revisions. If an agency that does such a large volume of construction were to investigate existing standards and make progressive (not arbitrary) suggestions, it is felt certain that there would be sufficient influence brought upon the legislature of the city to call for a revision of our existing Building Code.

5 NON-FIREPROOF CONSTRUCTION

New York City has perhaps the largest concentration of multi-story dwellings of any metropolitan area in this country. The greatest proportion of these dwellings, which are privately financed, have been and are still being constructed as "Class 3" non-fireproof buildings. These buildings must maintain competitive standards with respect to livability and benefits given to tenants. As they are built for a profit motive, cost and maintenance become prime factors. The fact that a majority of these buildings are built as non-fireproof has led to an investigation of this structural system.

In this section we present:

1. Application of non-fireproof construction to public housing.
2. Review of benefits and drawbacks of non-fireproof construction.



TYPICAL FLOOR PLAN — STRUCTURAL FRAMING

Application to Public Housing

There are a number of misconceptions about non-fireproof construction which should be rectified in order to allow fair evaluation of this structural system. The most obvious is the contorted shape most people associate with these buildings. This is brought about by an attempt on the part of a private investor to gain full utilization of a city lot by expanding the building to the outermost limits of the lot; and then cutting in deep courts and recesses, in order to give exterior perimeter to all rooms. When lot limitations cease to be a major concern, as would be the case on large housing projects, the simpler and more aesthetically pleasing slab shape can be readily laid out as part of the open site plan. A building of this type is illustrated in the rendering at the end of this section.

A "Class 3" non-fireproof multiple dwelling, as built to conform to New York City laws, consists of wood joist floor construction supported on masonry bearing walls, or non-fireproofed steel as shown in the structural framing plan. Partitions are wood stud construction, with ¾" plaster each side. Flooring is usually finished wood stripping on wood underflooring, but could be asphalt tile on a plywood subfloor. Ceilings are ¾" plaster. Public halls are separated from apartments by walls and floors with a three-hour fire resistive rating as shown in the typical plan on this page. The first tier also has a three-hour fire rating. Heights are limited to six stories above the first tier, requiring a twelve inch thick masonry exterior wall.

Experience has borne out the fact that non-fireproof construction averages ten to fifteen percent lower in overall costs than an equivalent fireproof structure. This saving would more often approach the fifteen percent differential when non-fireproof buildings are properly designed. A slab shape building derives further economies by eliminating corners, maintaining uniform joist dimensions between bearing walls, and minimizing the number of steel columns and girders. For example, the plans illustrated use a distance of 19'-4" clear between bearing walls, allowing maximum utilization of stock 20' joists.

ation to Public Housing

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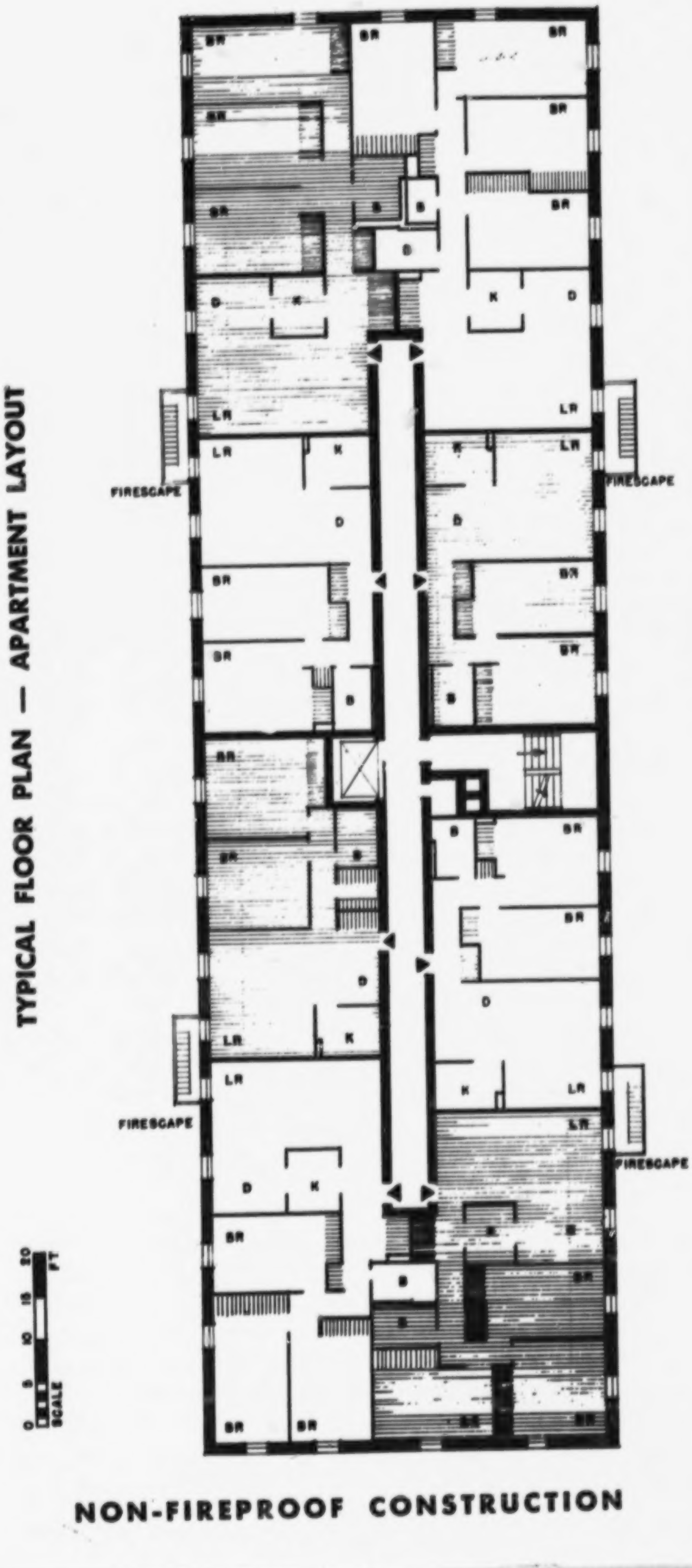
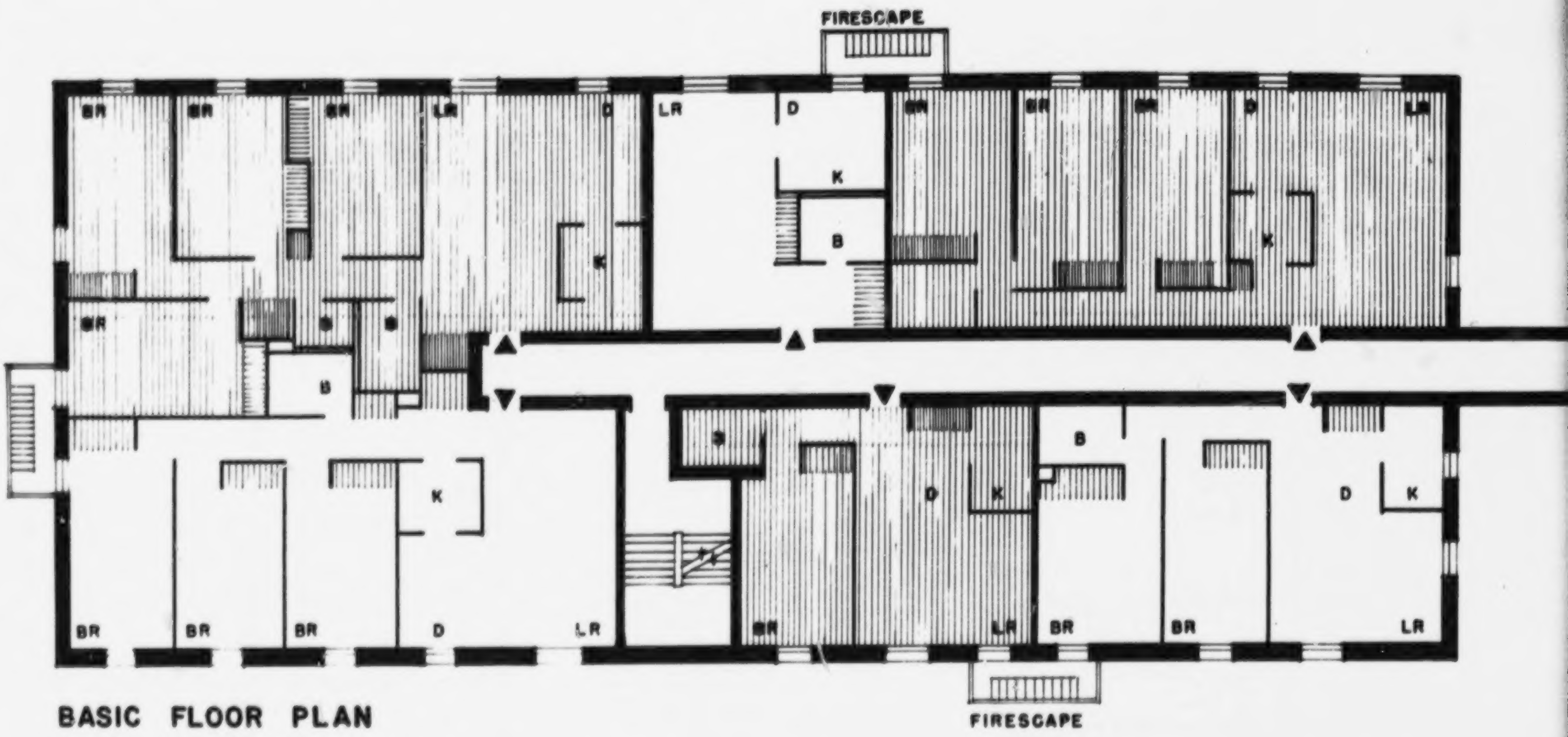


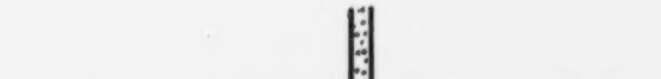
TYPICAL FLOOR PLAN — APARTMENT LAYOUT



BASIC FLOOR PLAN

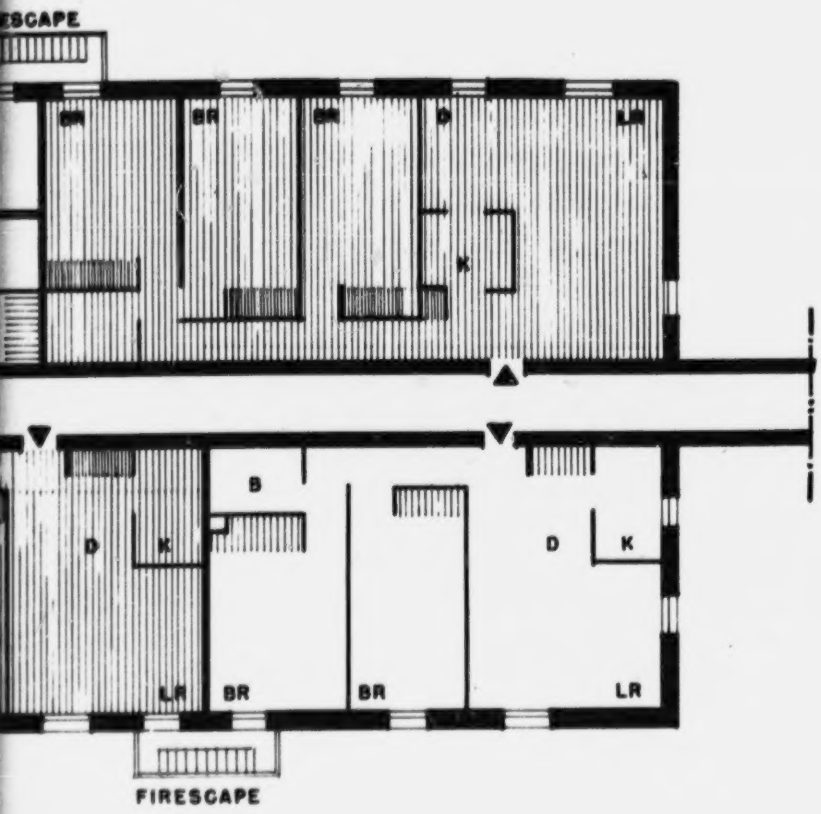
0 5 10 15 20
SCALE FT

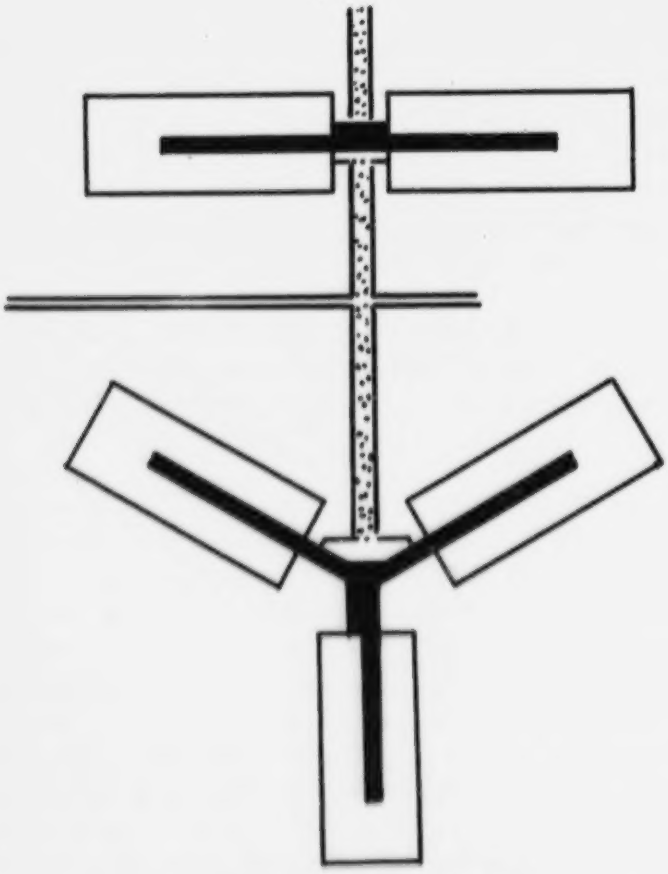
This type of construction is also flexible enough to find application in almost any overall shape desired, as shown by the sketches of "dumbell" or "Y-shaped" buildings, similar in general arrangement to those currently being built by the New York State Division of Housing. A common misconception about non-fireproof buildings is that they are totally lacking in fire protection. This is not so. Although the interior partitions and floor construction are not legally required to have any fire rating, by the nature of their construction they nevertheless attain very nearly a one-hour separation. In addition, the required three-hour rating at the first tier, effectively isolates the cellar, which has been found to be the major source of fires in multiple dwellings. Increased maintenance costs, commonly attributed to non-fireproof buildings, is another misconception. In actuality, the finished surfaces are or can be of the same materials as now used by the Division of Housing, namely, plaster partitions, asphalt tile floors, brick walls. The only increase in maintenance costs required would be periodic painting of fire escapes.



PLAN ASSEMBLIES

NON-FIREPROOF CONSTRUCTION





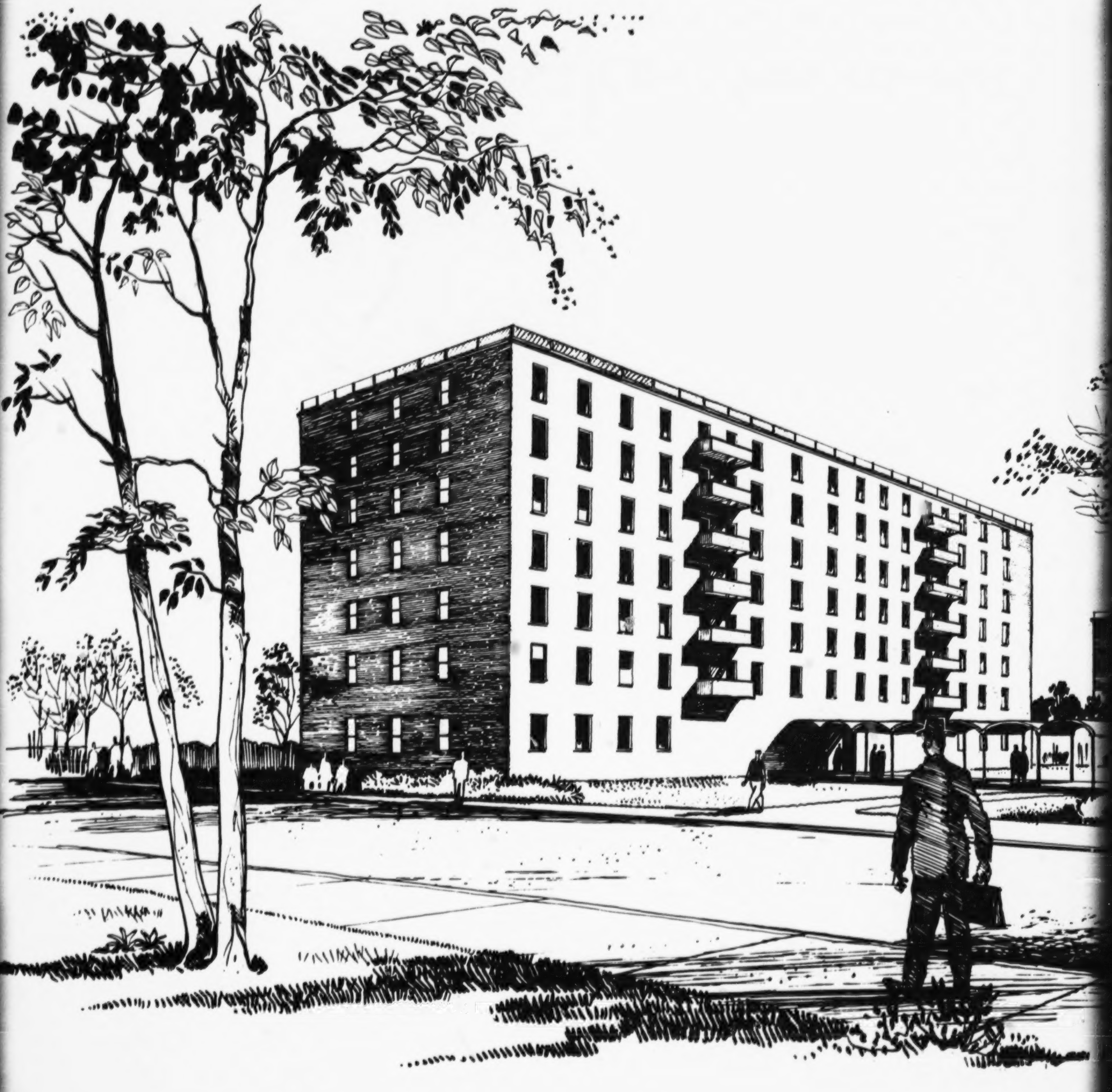
PLAN ASSEMBLIES

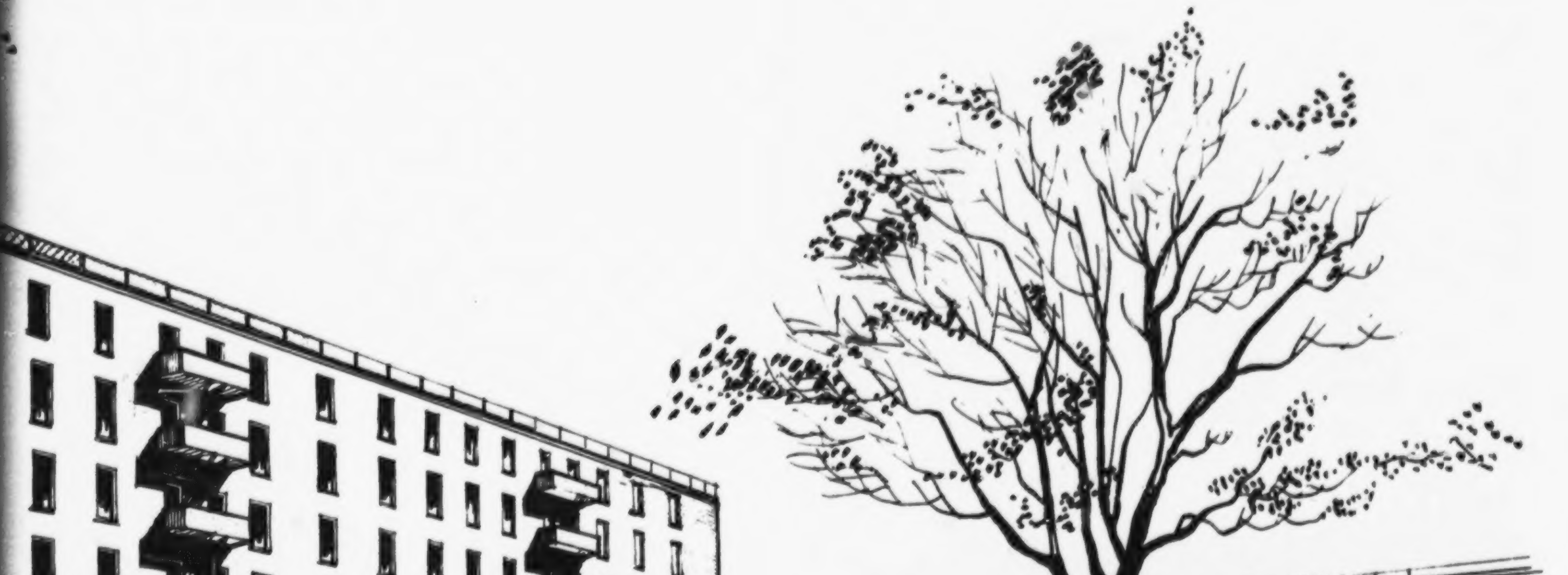
Benefits and Drawbacks

The Division of Housing could certainly initiate the adoption of non-fireproof construction in areas where land values permit the use of medium-rise buildings. In projects where high-rise dwellings are felt to be necessary, the introduction of some non-fireproof medium-rise buildings should be considered, not only from the point of view of cost savings, but because they introduce a more human scale into an otherwise titanic building grouping. They also create an area of transition between the high-rise buildings and the surrounding neighborhood which usually consists of 4- and 5-story tenements.

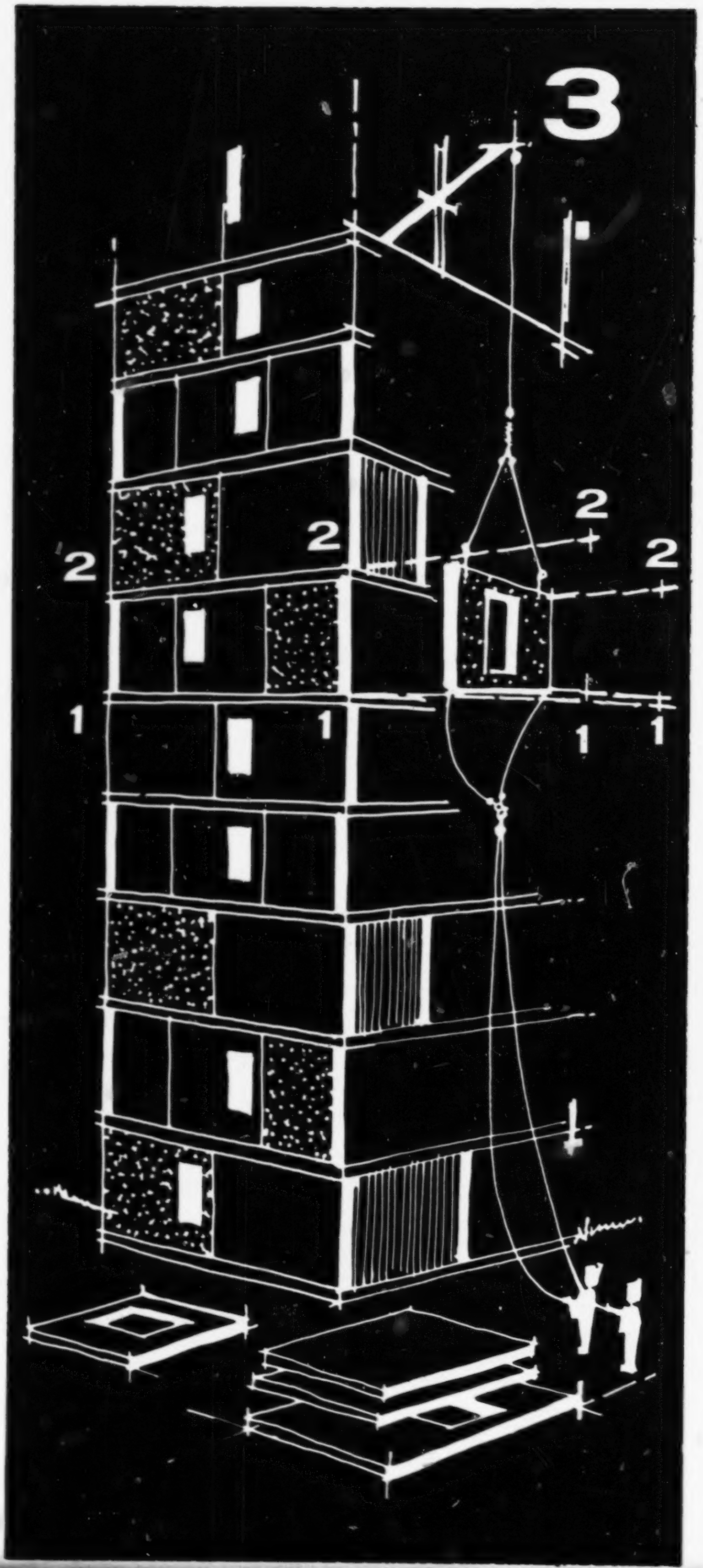
The actual drawbacks of non-fireproof buildings are not as serious as they are annoying. The first and most prominent is the necessity of placing fire escapes on the exteriors. These are as a rule adverse visual elements, deterrents to privacy, and temptations to burglars. Another drawback is the problem of vermin, since both floor and partition construction are hollow. The increased cost of insurance as compared to fireproof construction (15 cents per hundred dollars vs. 5 cents per hundred dollars) is a further disadvantage.

These drawbacks can, to a greater or lesser degree, be alleviated. The fire escapes can be designed as an aesthetic accent to an otherwise drab facade. They can, for example, be used to good advantage to introduce color into the design. The use of new materials in balcony construction along with new thinking in fire-escape design could easily result in an attractive, pleasing element, at very little increase in cost. Some of these ideas are shown in the rendering at right. Judicious placing of fire-escape balconies at windows that can be kept locked and curtained when desired (at one of two windows in a room) would eliminate the problems of privacy and theft. The most serious problem, and the most difficult to control, is the problem of vermin. Pest control, unfortunately, cannot be built into this type of building, but proper housekeeping, and a reasonable pest-control program will to all intents and purposes eliminate this difficulty. The increased insurance cost is insignificant compared to the large savings in construction costs, especially if both are amortized over a fifty-year period.




R. Corbelletti

NON-FIREPROOF CONSTRUCTION



CHAPTER THREE – THE EXTERIOR WALL

Visually the predominant element of a New York City public housing project is the exterior wall; the tall thin buildings with their small windows appear to be almost entirely wall. It seemed reasonable to give special attention to the possibility of reducing the cost of this important element.

It soon became apparent that a complete analysis of wall costs would have to take into account more than just the construction cost of the wall. Such additional factors as the heat loss through the wall, the thickness of the wall, and the long-term maintenance and operating costs would have to be considered.

The present standard wall of the New York State Division of Housing consists of four inches of common brick, backed up by six inches of cinder block, furred and plastered. This wall is low in first cost and low in maintenance cost; on the other hand it is bulky, and it is poor insulation and thus high in operating (heating) costs.

Of some forty wall assemblies considered, twelve were selected for detailed analysis in comparison with the standard wall.

For each of the twelve examples a tabulation of the materials used, their thickness, cost, and thermal resistance is presented and the results are compared with the standard wall. Of the twelve examples, seven are masonry and five are prefabricated panel walls of one type or another. Of the masonry walls, three are solid — essentially variations of the standard wall — and four are cavity walls. Of the five prefabricated walls, one is of concrete and the other four are metal panels. All but one of the twelve walls are capable of meeting the New York City building code requirement for a two-hour fire rating.

In the second part of the Chapter, the effect of the thermal transmission value of the wall upon the overall cost picture, is analyzed in some detail. Studies of the economies of insulation have usually been confined to the question of the number of years of fuel savings required to amortize the cost of the insulation. Savings due to a reduction in the size of the heating plant, made possible by the addition of insulation to the wall, have generally been ignored. It was felt by the research staff that this was an important cost factor which should not be neglected, and it was therefore included in the present analysis. Since there is little precedent for this type of study, the methods used as well as the calculations are given in full.

The method, in brief, involves the translation of the heating plant cost into cost per square foot of wall, and adding this cost to the construction cost of the wall. Thus a direct cost comparison can be made between a low cost, high heat loss wall (such as the standard wall) and a higher cost, low heat loss wall.

For the heating cost studies four walls were selected from the twelve previously analyzed. They included two masonry walls — one solid and one cavity — and two prefabricated walls — one concrete and one metal. These four examples are compared, of course, with the standard wall.

Since the window is also part of the exterior wall, and the part where the largest heat loss occurs, it was necessary to include it in the heat cost study. The economic possibilities of insulating the windows, as well as the walls, was analyzed.

THE EXTERIOR WALL

This section will consider the exterior wall with two objectives: first, a look at various exterior wall components presently being used to arrive at a thin, well constructed, easily and quickly erected wall, having required fire rating, and equal to or below present costs; second, an examination of the ways and means of insulating the present standard wall (or a modified version of it) with available insulating materials in order to reduce the size of the heating plant and the quantity of fuel required for heating the buildings.

On New York City public housing work, the reinforced concrete frame is enclosed with a heavy brick and block wall. The main virtue of this wall is that it can be laid up very economically under favorable weather conditions to produce a serviceable enclosure requiring little maintenance. This exterior wall:
Absorbs moisture; leaks
Imposes heavy load on structure
Takes up critical floor area
Has limited texture and color variation
Is poor insulation
Uses excessive window and door trim
Requires scaffolding to erect
Presents storage and transportation problems
Defeats possible prefabrication
Can be installed only in good weather

A wall system replacing the present "standard" must be an acceptable substitute which would not only correct all or most of the problems noted, but should, in addition, meet following basic aims:

1. Fire rating — two hours
head to sill above,
vertical distance 3 feet
2. Wind loads — 30-40 PSF;
air tight - water tight.
3. Purchase — No proprietory items
adequate supplies
4. Erection — Easy shop fabrication
Easy field assembly
Adjustable attachment
Structurally sound
5. Insulation — U-value of 0.10 to 0.15 Btu,
using available materials

With this introduction to the exterior envelope of public housing we present on the following pages:

1. A review of twelve exterior walls.
   These exterior walls were selected by the research staff from forty walls studied. They are all compared with the "Standard" (S) wall at right. Two groups of walls are investigated: walls of masonry components (Nos. 1 to 7), and panel-type exterior walls (Nos. 8 to 12). Each is detailed horizontally and vertically as applied to a typical New York State Division of Housing structure. Each assumes standard flashing, jointing details and window installations and is erected using familiar building techniques. Cost of lintels, anchors, girts, clips, bracing, etc., is prorated over total wall. Percentage comparison of cost, U-value and thickness are noted on section followed by a brief comment about each wall.
2. Itemized chart of twelve exterior walls.
3. Comparative chart of twelve exterior walls.
4. Discussion and detail of two prefabricated walls (No. 8 and No. 10).
5. Insulation methods for the exterior wall.
   With a review of the exterior wall completed, attention is directed to ways and means of insulating the exterior wall. In this portion of the study the following standards apply:
   - **a.** Unit prices
     volume prices, New York City area, March 1958
     (averaged from four price consultants).
   - **b.** Thermal resistance
     HVAC guide (1957) or from manufacturer's data.
   - **c.** Fenestration
     infiltration is calculated; window areas
     taken off project drawings.
   - **d.** Wall faces
     1/fo - outside, 15 MPH = .17
     1/fi - inside, still = .61
   - **e.** Project data
     from complete set of project drawings and
     specifications furnished by New York State
     Division of Housing.

TYPICAL PUBLIC HOUSING WALL
TOTAL WIDTH: 12¾"
U-VALUE: 0.241
COST IN PLACE: $2.63

s introduction to the exterior envelope of ousing we present on the following pages:

view of twelve exterior walls.
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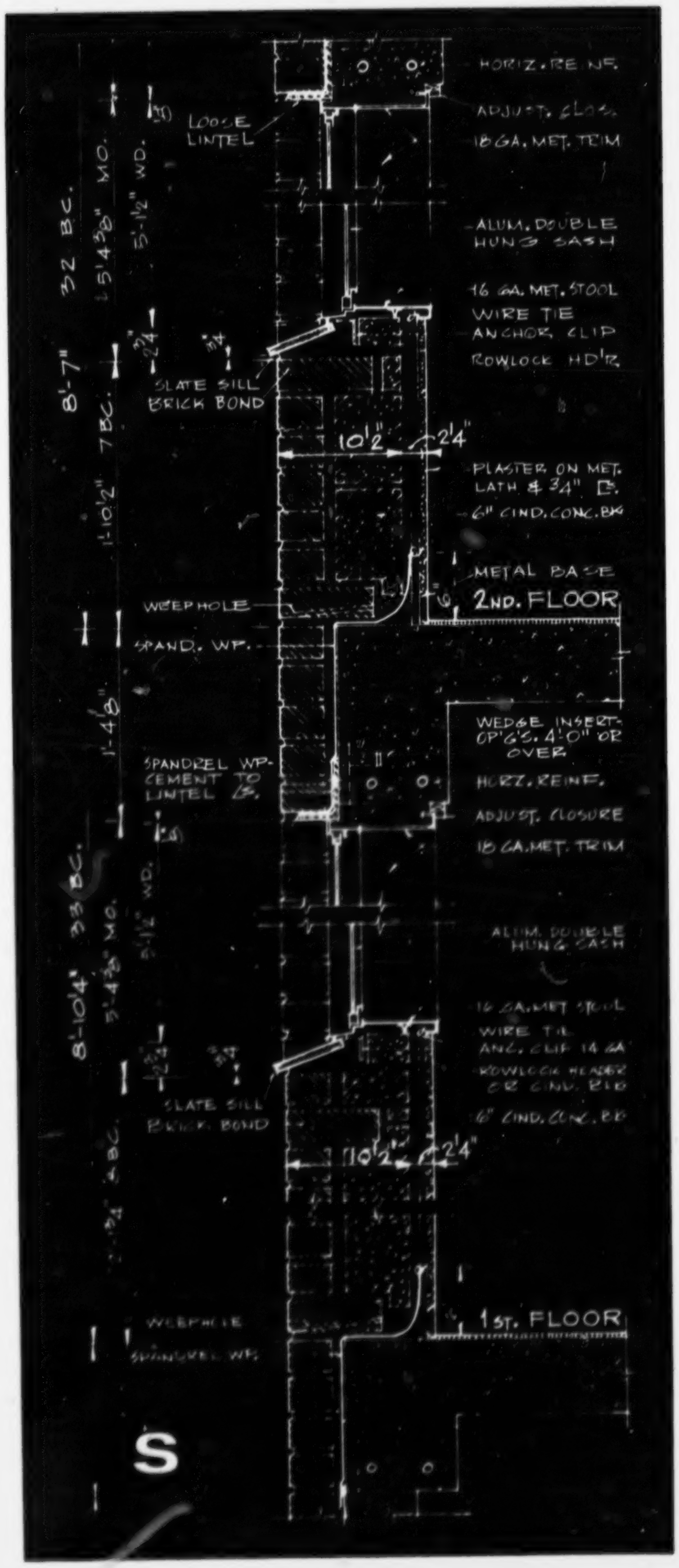
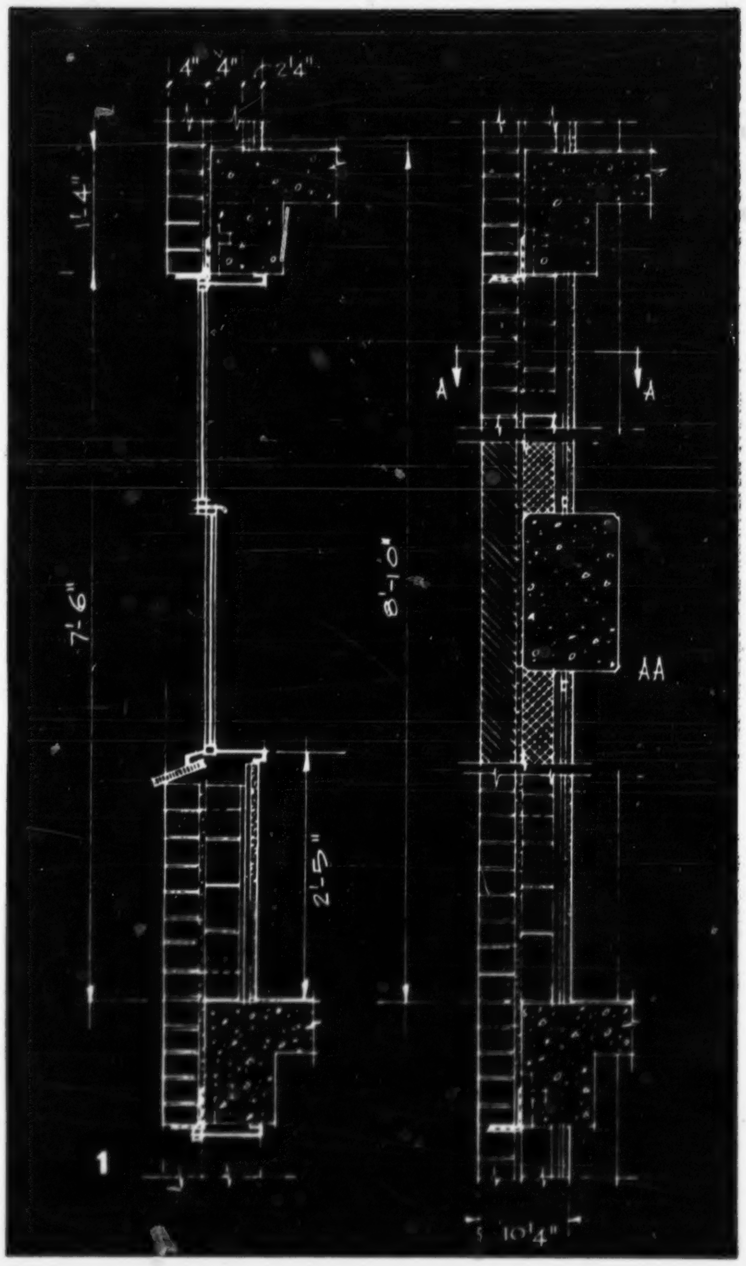


HORIZ. REINF.
ADJUST. CLOS.
18 GA. MET. TRIM
LOOSE LINTEL
32 BC.
5'4 3/8" MO.
5'-1 1/2" WD.
ALUM. DOUBLE HUNG SASH
16 GA. MET. STOOL
WIRE TIE ANCHOR CLIP
ROWLOCK HD'R
8'-7"
7 BC.
2 1/4"
3/4
SLATE SILL BRICK BOND
10 1/2"
2 1/4"
PLASTER ON MET. LATH & 3/4" F.
6" CIND. CONC. BK
1'-10 1/2"
METAL BASE
2ND. FLOOR
WEEPHOLE
SPAND. WP.
1'-4 1/8"
WEDGE INSERT- OP'G'S. 4'-0" OR OVER
SPANDREL WP- CEMENT TO LINTEL L.
HORZ. REINF.
ADJUST. CLOSURE
18 GA. MET. TRIM
8'-10 1/4"
33 BC.
5'-4 3/8" MO.
5'-1 1/2" WD.
ALUM. DOUBLE HUNG SASH
16 GA. MET. STOOL
WIRE TIE ANC. CLIP 14 GA
ROWLOCK HEADER OR CIND. BLK
6" CIND. CONC. BK
SLATE SILL BRICK BOND
10 1/2"
2 1/4"
1ST. FLOOR
WEEPHOLE
SPANDREL WP.
S

1 A Review of Twelve Exterior Walls



New York State Division of Housing modified wall:

"Standard" wall reduced in size by use of 4" backup block in lieu of present 6" block — strength of wall adequate — area gained added to usable floor space — a cheaper wall (even with applied mastic coating inside) — a colder wall: but higher U-value easily offset by more than adequate safety factors presently applied to total heat loss calculations — no attempt is made to get a warmer wall, but simply a thinner wall resulting in immediate gain in floor space or in reduction of the total constructed floor area.

Wall materials	**Cost-per SF**	**R**
Outside surface	—	0.1
4" common brick	$1.41	0.8
4" cinder concrete block	.60	1.0
¾" channels & metal lath 3.4#	.21	0.9
¾" plaster (3 coats)	.28	0.2
3 coats paint (oil base)	.07	–
Inside surface	—	0.6
	$2.57	3.7
		U=0.26

% of base: cost=**97.7**; U-value=**111.2**; thickness=**80.**

R	**Cost-per SF**	**Wall materials**
0.17	—	Outside surface
0.80	$1.41	4" common brick
—	.10	¼" cement mortar
4.00	.17	1" Styrofoam
—	.05	Tie clips
1.00	.60	4" cinder concrete block
0.91	.21	¾" channels & metal lath 3
0.23	.28	¾" plaster (3 coats)
—	.07	3 coats paint (oil base)
0.61	—	Inside surface
7.72	$2.89	
U=0.129	.03	Large lintel angles prorate
	$2.92	

% of base: cost=**111.0**; U-value=**53.5**; thickness=**9**

*Styrofoam is The Dow C

A Review of Twelve Exterior Walls

all materials	Cost-per SF	R
tside surface	—	0.17
common brick	$1.41	0.80
cinder concrete block	.60	1.00
channels & metal lath 3.4#	.21	0.91
plaster (3 coats)	.28	0.23
oats paint (oil base)	.07	—
de surface	—	0.61
	$2.57	3.72
		U=0.268

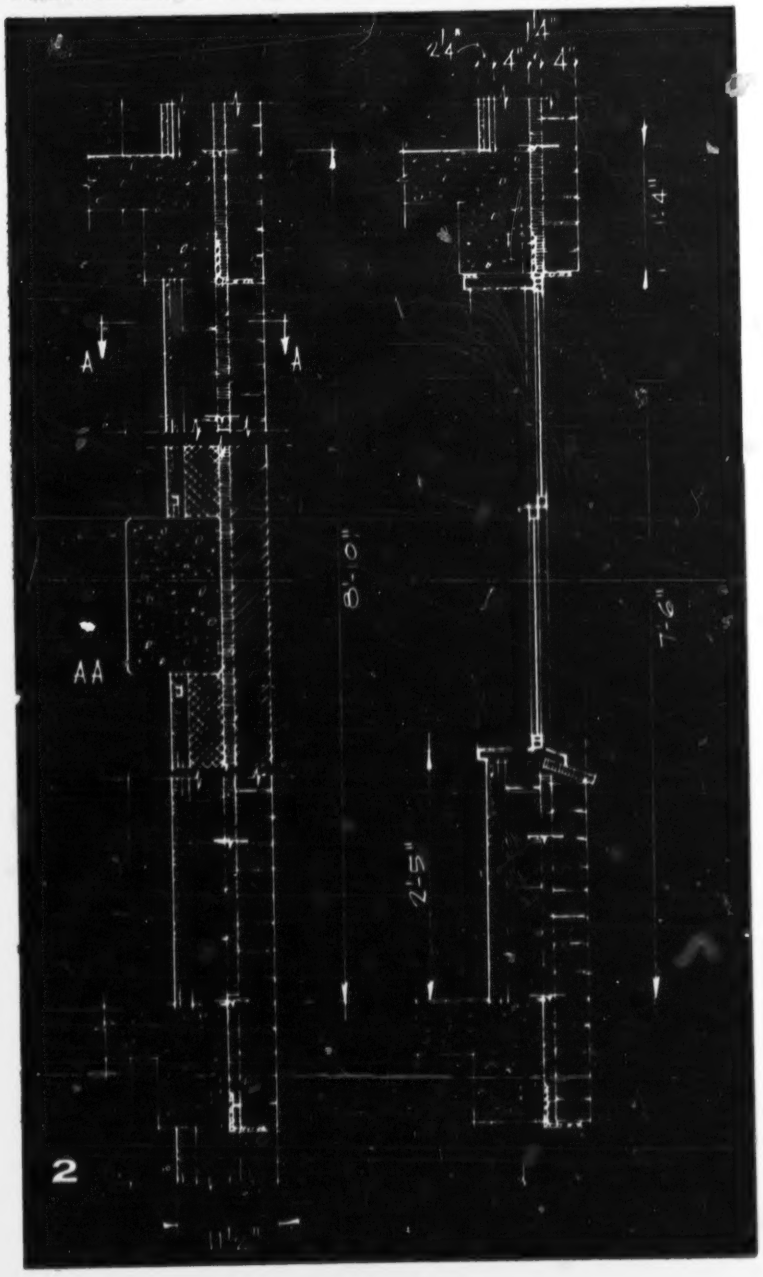
of base: cost=**97.7**; U-value=**111.2**; thickness=**80.3**

R	Cost-per SF	Wall materials
0.17	—	Outside surface
0.80	$1.41	4" common brick
—	.10	¼" cement mortar
4.00	.17	1" Styrofoam
—	.05	Tie clips
1.00	.60	4" cinder concrete block
0.91	.21	¾" channels & metal lath 3.4#
0.23	.28	¾" plaster (3 coats)
—	.07	3 coats paint (oil base)
0.61	—	Inside surface
7.72	$2.89	
U=0.129	.03	Large lintel angles prorated
	$2.92	

% of base: cost=**111.0**; U-value=**53.5**; thickness=**90.1**

New York State Division of Housing Insulated Wall:

A modified "standard" wall with 1" polystyrene rigid foam (Styrofoam*) added between brick and block. Brick and backup tied with wall clips. Insulation applied directly behind brick to cover both backup material ('infill' panel) and structural frame for maximum insulation with resulting savings in heat plant and fuel costs — this wall used as basic wall in heating study in this section (see "Insulation methods for the exterior wall"). Use of an extra inch of Styrofoam would permit direct plastering to backup block. This modification is also used in the heating study.



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*Styrofoam is The Dow Chemical Company's registered trademark for its extruded expanded polystyrene.

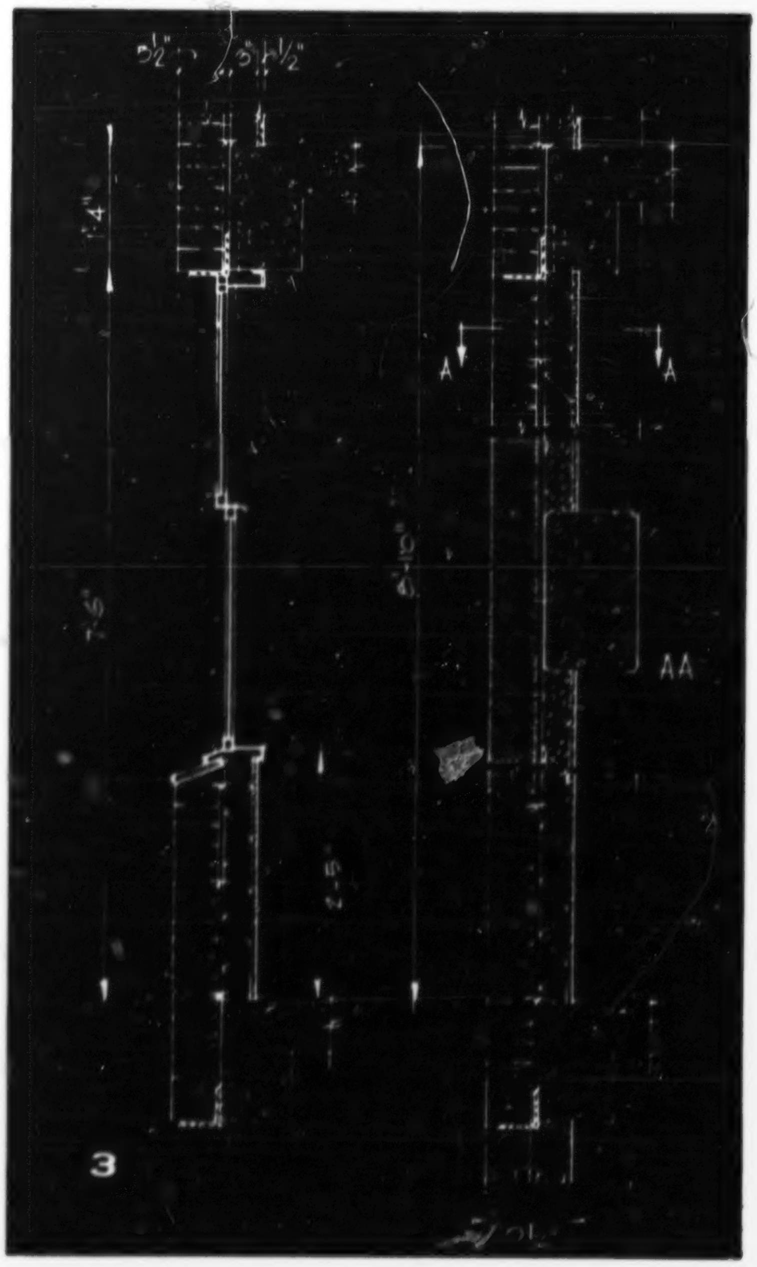
"SCR" Brick Wall:

This wall utilizes 2 currently available building units: Structural Clay Products brick—2" x 5½" x 11½" and cement-wood fiber block—3" x 18½" x 32" to produce a wall quickly erected with resulting savings in construction time — gap permits direct plastering and allows use of Styrofoam insulation between "SCR" brick and structural frame if desired — a thin masonry wall (when properly reinforced) providing an exterior wall consistent with present code standards and thin enough (25% less) to give substantial savings both in constructed floor space and reduced metal window frames.

R	Cost-per SF	Wall materials ▶
0.17	—	Outside surface
0.80	$1.41	4" common brick
0.91	.08	Clip anchors
6.69	.39	3" cement-wood fiber block
0.23	.22	½" plaster (2 coats)
—	.07	3 coats paint (oil base)
0.61	—	Inside surface
9.41	$2.17	

U=0.106

% of base: cost=**82.5**; U-value=**43.9**; thickness=**74.5**



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◀Wall materials	Cost-per SF	R
Outside surface	—	0.17
6" "SCR" brick	$1.84	0.68
¼" bituminous mastic coat	.14	—
Special 'SCR' clips	.08	—
3" cement-wood fiber block	.39	6.69
½" plaster (2 coats)	.22	0.23
3 coats paint (oil base)	.07	—
Inside surface	—	0.61
	$2.74	8.38
Add. angles prorated per SF	.03	U=0.119
	$2.77	

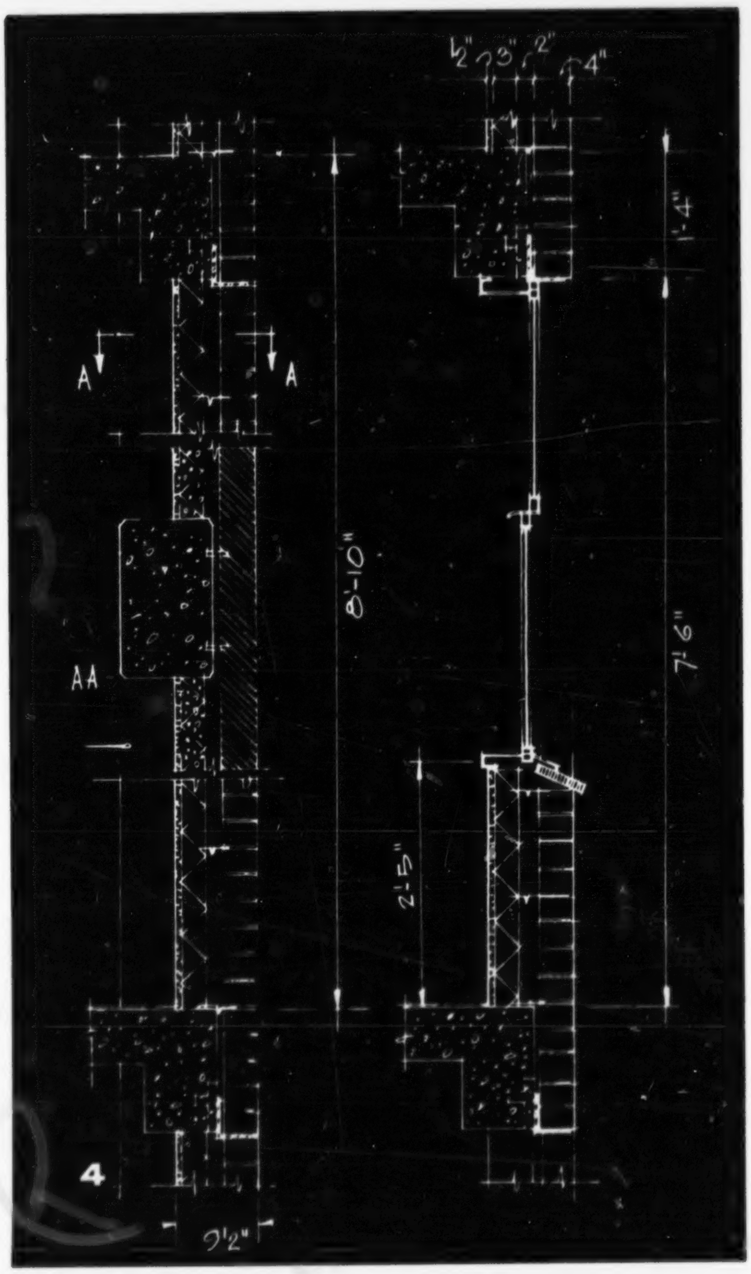
% of base: cost=**105.3**; U-value=**49.3**; thickness=**74.5**

Cost-per SF	Wall materials
—	Outside surface
$1.41	4" common brick
.08	Clip anchors
.39	3" cement-wood fiber block
.22	½" plaster (2 coats)
.07	3 coats paint (oil base)
—	Inside surface
$2.17	

e: cost=**82.5**; U-value=**43.9**; thickness=**74.5**

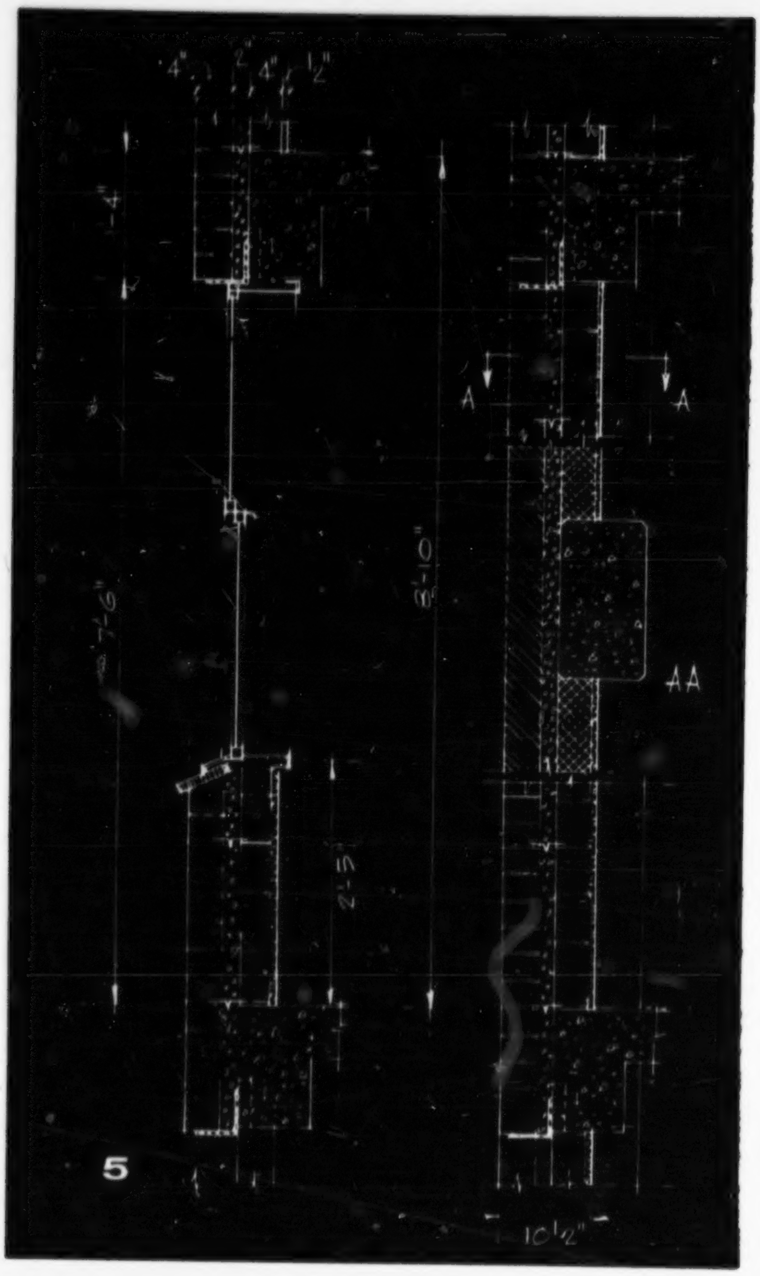
rials	Cost-per SF	R
ce	—	0.17
k	$1.84	0.68
s mastic coat	.14	—
clips	.08	—
od fiber block	.39	6.69
coats)	.22	0.23
(oil base)	.07	—
	—	0.61
	$2.74	8.38
prorated per SF	.03	U=0.119
	$2.77	

cost=**105.3**; U-value=**49.3**; thickness=**74.5**



4

Cavity Wall No. 1:
The cheapest masonry wall investigated — could immediately replace present New York State Division of Housing wall with 17.5% less erected cost — plus added benefits derived from excellent U-value (56.1% reduction) and reduced width (25.5% reduction) same as "SCR" brick wall. If properly erected and adequately tied to backup and structural frame gives thin exterior masonry wall for public housing work. Only major shortcoming is inability to cover entire exterior (structural frame as well as "infill" panels) with full insulating property of wall.



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◀**Wall materials**	**Cost-per SF**	**R**
Outside surface	—	0.17
4" common brick	$1.41	0.80
Wall ties	.06	—
2" poured insulating fill	.23	8.30
4" cinder concrete block	.60	1.00
½" plaster (2 coats)	.22	0.23
3 coats paint (oil base)	.07	—
Inside surface	—	0.61
	$2.59	11.11
Add. angles prorated per SF	.03	U=0.090
	$2.62	

% of base: cost=**99.9**; U-value=**37.3**; thickness=**82.3**

Cavity Wall No. 2:

Insulated cavity wall requiring but slight revision of lintels of present wall to give masonry wall equal in cost to "standard" (see first page of this section) but with reduction of 62.7% of present U (highest of basic wall types) — complete insulating benefits of this wall dependent upon very careful application of loose insulation in entire cavity (close supervision — thus not fully endorsed) — but since low U-value is possible for entire area of exterior wall, this wall and the following should be given careful evaluation under actual field tests.

R	**Cost-per SF**	**Wall materials** ▶
0.17	—	Outside surface
0.80	$1.41	4" common brick
—	.06	Wall ties
8.30	.23	2" poured insulating fill
1.00	.60	4" cinder concrete block
—	.10	Clean and point joints
—	.14	2 coats latex paint
0.61	—	Inside surface
10.88	$2.54	
U=0.092	.03	Add. angles prorated per SF
	$2.57	

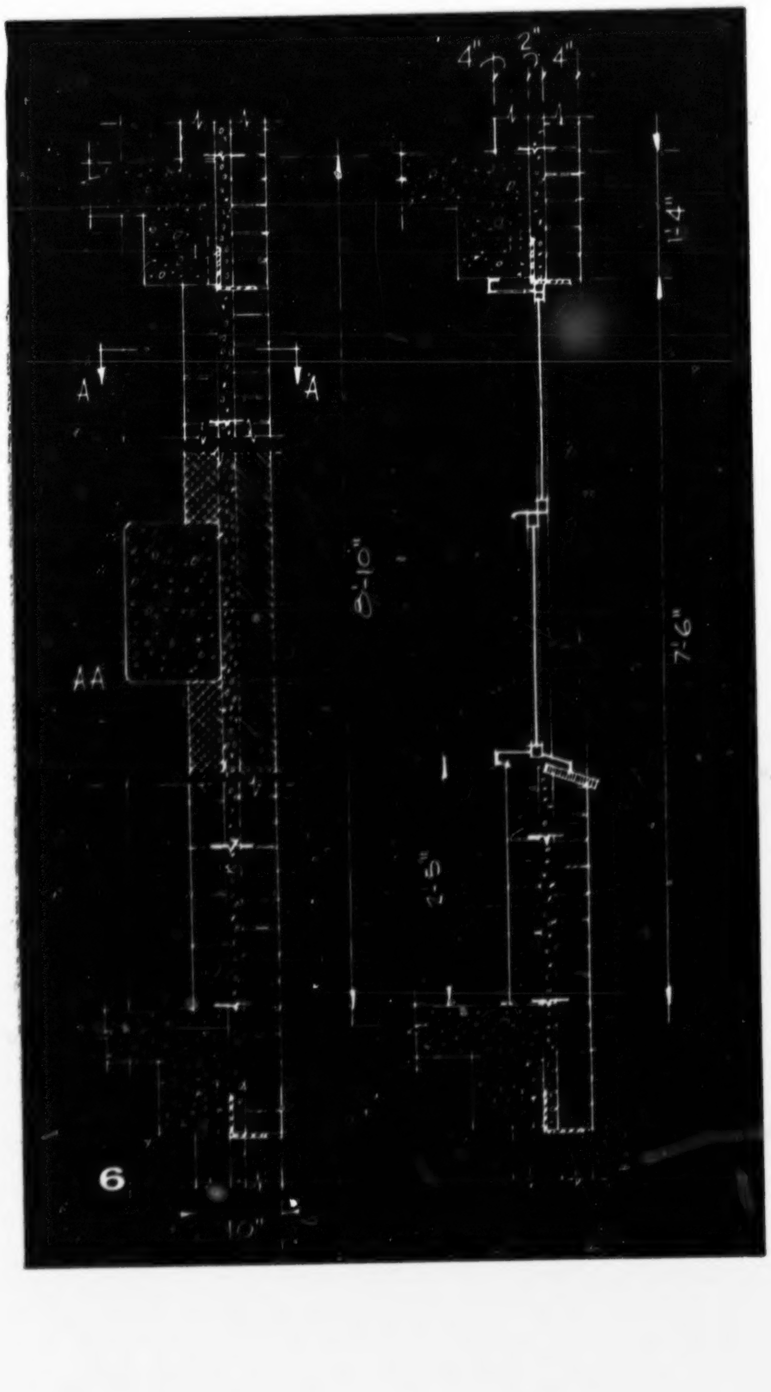
% of base: cost=**97.7**; U-value=**38.5**; thickness=**78.5**

ll materials	Cost-per SF	R
ide surface	—	0.17
ommon brick	$1.41	0.80
l ties	.06	—
oured insulating fill	.23	8.30
inder concrete block	.60	1.00
plaster (2 coats)	.22	0.23
ats paint (oil base)	.07	—
le surface	—	0.61
	$2.59	11.11
. angles prorated per SF	.03	U=0.090
	$2.62	

of base: cost=**99.9**; U-value=**37.3**; thickness=**82.3**

Cavity Wall No. 3:

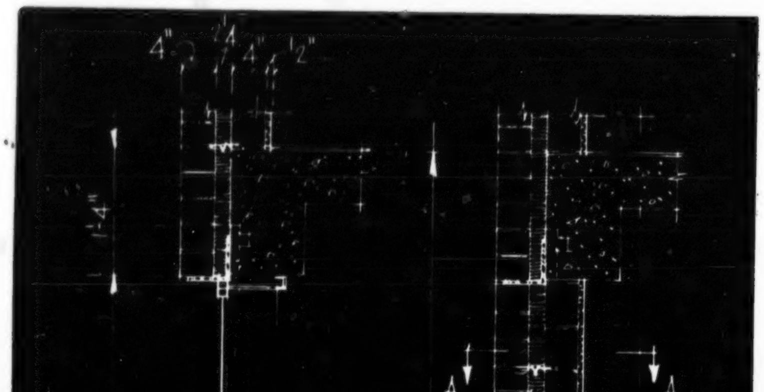
Second insulated cavity wall, equal to or less than present masonry wall costs — low erected cost based upon omission of plaster finish on interior wall: setting off additional cost of pointing joints (requiring tolerance of "cinder block look") against cost of plaster — latex paint used for interior surface. A masonry wall with a low U-value representing immediate and future savings in heat costs. Cavity walls 2 and 3 have additional cost of large lintels prorated over entire exterior wall.



R	Cost-per SF	Wall materials
0.17	—	Outside surface
0.80	$1.41	4" common brick
—	.06	Wall ties
8.30	.23	2" poured insulating fill
1.00	.60	4" cinder concrete block
—	.10	Clean and point joints
—	.14	2 coats latex paint
0.61	—	Inside surface
10.88	$2.54	
U=0.092	.03	Add. angles prorated per SF
	$2.57	

% of base: cost=**97.7**; U-value=**38.5**; thickness=**78.5**

Cavity Wall No. 4:
Two suggested alternate details (see itemized chart — this section) give this "cavity" wall (cavity filled with 2" Styrofoam) an amazing flexibility in use of commonly available building materials with resulting wide range in erected costs: $2.29-$2.82 and low U-values. Alternate details using exposed cinder block (painted with prime and top coats of epoxy paint and/or unpainted) strongly urged on trial basis because of low cost: $2.29 and U-value: 0.061 — this construction detail possible because of very low water absorption of Styrofoam.



R	Cost-per SF	Wall materials
0.17	—	Outside surface
0.13	—	1½" dense conc. (broom fin.)
8.00	$2.60	2" Styrofoam
0.13	—	1½" dense conc. (rough fin.)
0.91	.21	¾" channels & metal lath 3.4#
0.23	.28	¾" plaster (3 coats)
—	.07	3 coats paint (oil base)
0.61	—	Inside surface
10.97 U=0.091	$3.16	

% of base: cost=**120.1**; U-value=**38.4**; thickness=**56.8**

Wall materials	Cost-per SF	R
Outside surface	—	0.17
4" common brick	$1.41	0.80
¼" cement mortar	.10	—
2" Styrofoam	.34	8.00
Anchor clips	.05	—
4" cinder concrete block	.60	1.00
½" plaster (2 coats)	.22	0.23
3 coats paint (oil base)	.07	—
Inside surface	—	0.61
	2.79	10.81
Add. angles prorated per SF	.03	U=0.092
	$2.82	

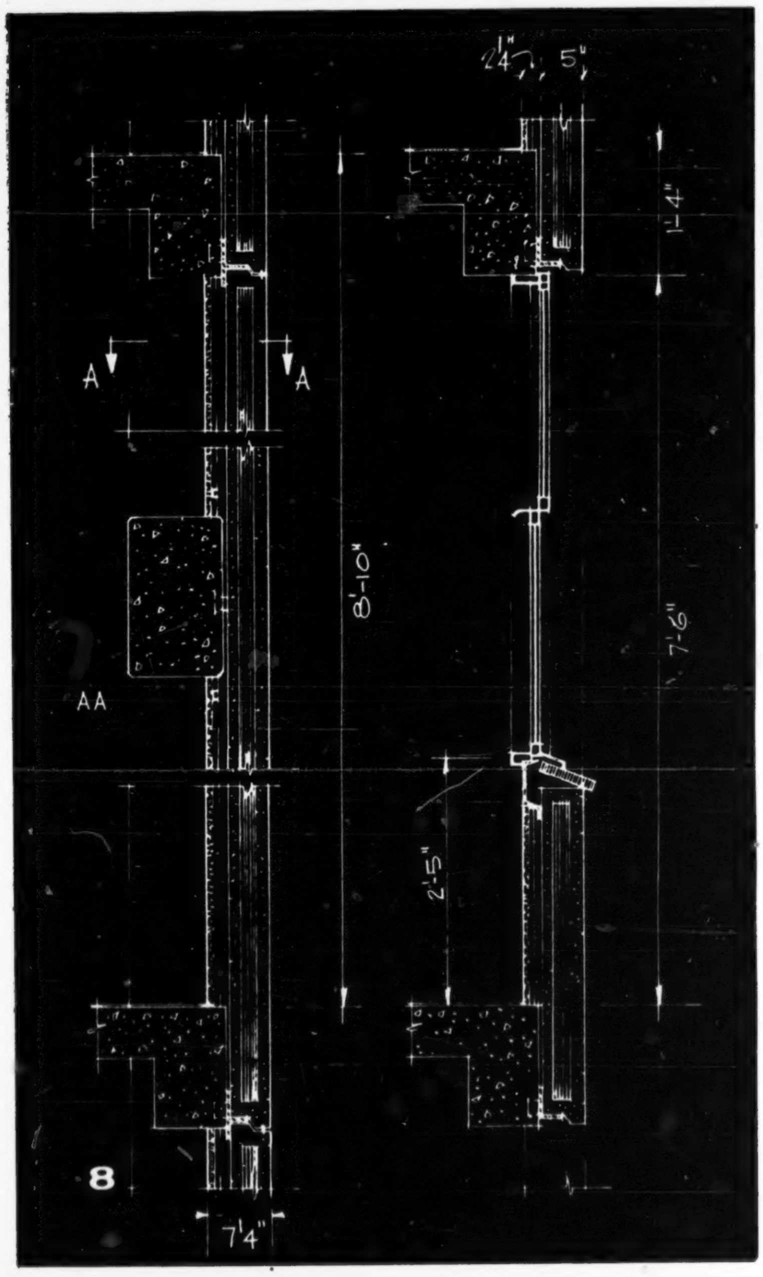
% of base: cost=**107.2**; U-value=**38.5**; thickness=**85.1**

Cost-per SF	Wall materials
—	Outside surface
—	1½" dense conc. (broom fin.)
$2.60	2" Styrofoam
—	1½" dense conc. (rough fin.)
.21	¾" channels & metal lath 3.4#
.28	¾" plaster (3 coats)
.07	3 coats paint (oil base)
—	Inside surface
$3.16	

: cost=**120.1**; U-value=**38.4**; thickness=**56.8**

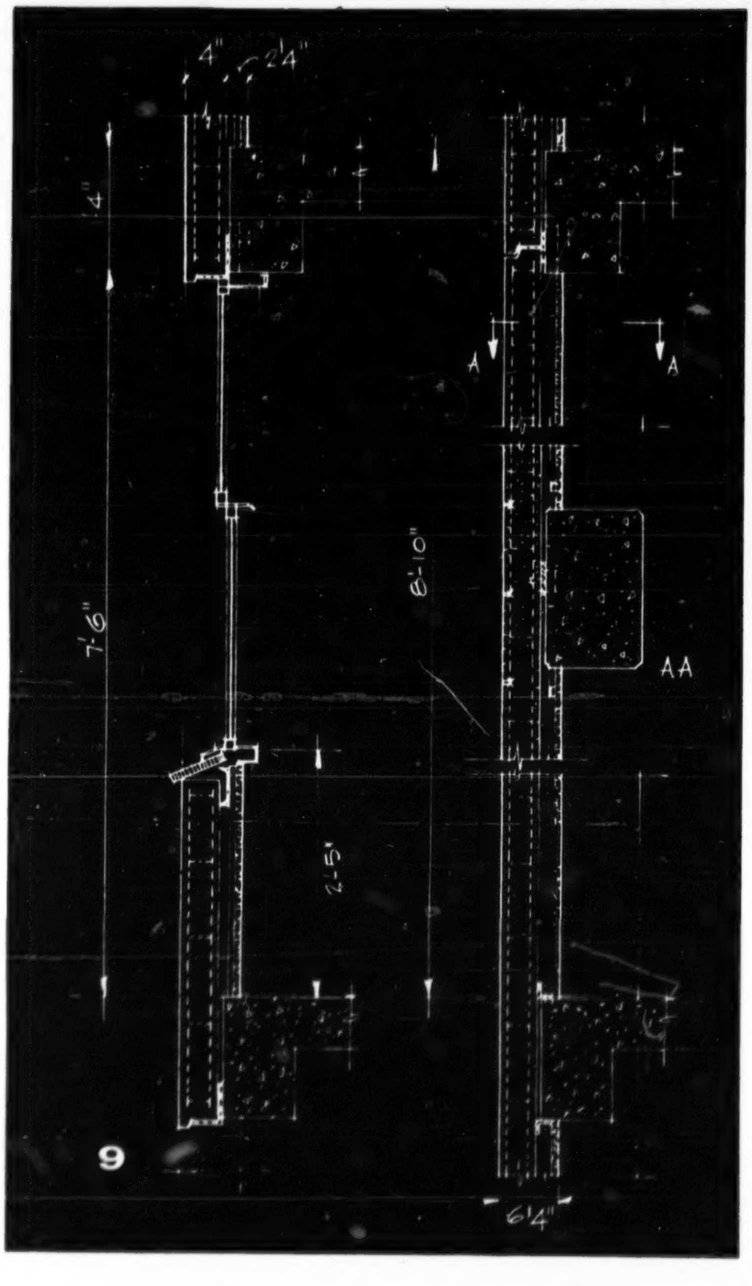
erials	Cost-per SF	R
ace	—	0.17
brick	$1.41	0.80
mortar	.10	—
n	.34	8.00
	.05	—
ncrete block	.60	1.00
(2 coats)	.22	0.23
t (oil base)	.07	—
e	—	0.61
	2.79	10.81
prorated per SF	.03	U=0.092
	$2.82	

cost=**107.2**; U-value=**38.5**; thickness=**85.1**



8

Panel Wall No. 1:
Precast, concrete, "panel-type" wall system successfully tested and used in many commercial structures — this wall system shown in detail (see details — this section) because investigation has shown it to be most versatile of panel walls studied: permitting preformed window openings, fast and easy erection, ease of combined erection with present standard wall (and/or other panel systems) to achieve a varied wall texture — suggested omission of plastering makes this wall about equal in cost to present wall.



Panel Wall No. 2:
A low-cost, fully-fireproof panel-wall system presently under experimental study — only panel wall studied where use of exterior stainless steel facing (resulting in negligible upkeep) was found to be acceptable cost wise — omission of furring channels (see itemized chart — this section) while raising U-value (still a low 0.123) places this wall on structural frame for about the same cost as present "standard" masonry wall, with resulting heat plant savings and with greatest (51%) reduction of wall size.

◀**Wall materials**	**Cost-per SF**	**R**
Outside surface	—	0.17
Stainless steel-ribbed — 28 GA.		
Type 430- #2 fin-.45 lab. & .45 mat.	$ .90	—
Wire mesh welded to S.S.	.08	—
Vermiculaite conc.-1:6 mix-30 PCF	.62	6.15
Wire mesh-clips to outside mesh	.10	—
¾" channels & metal 3.4#	.21	0.91
¾" plaster (3 coats)	.28	0.23
3 coats paint (oil base)	.07	—
Inside surface	—	0.61
	$2.26	8.07
Erection — prorated per SF	.50	U=0.123
	$2.76	

% of base: cost=**104.9**; U-value=**51.0**; thickness=**49.0**

R	**Cost-per SF**	**Wall materials**
0.17	—	Outside surface
—	$ .50	20 ga. steel — vinyl coated & rib
0.70	.38	2½" gypsum boards — cemente
		Center steel splines &
—	.12	edging channels — prorated
0.70	.38	2½" gypsum boards cemented
—	.45	18 ga. metallic coated steel
5.55	.10	1½" batt insulation
0.91	.21	¾" channels & metal lath 3.4#
0.23	.28	¾" plaster (3 coats)
—	.07	3 coats paint (oil base)
0.61	—	Inside surface
8.87	$2.49	
U=0.112	.40	Erection — prorated per SF
	$2.89	

% of base: cost=**109.8**; U-value=**46.4**; thickness=**58.8**

Wall materials	Cost-per SF	R
Outside surface	—	0.17
Stainless steel-ribbed — 28 GA.		
Type 430- #2 fin-.45 lab. & .45 mat.	$ .90	—
Wire mesh welded to S.S.	.08	—
Vermiculaite conc.-1:6 mix-30 PCF	.62	6.15
Wire mesh-clips to outside mesh	.10	—
¾″ channels & metal 3.4#	.21	0.91
¾″ plaster (3 coats)	.28	0.23
3 coats paint (oil base)	.07	—
Inside surface	—	0.61
	$2.26	8.07
Erection — prorated per SF	.50	U=0.123
	$2.76	

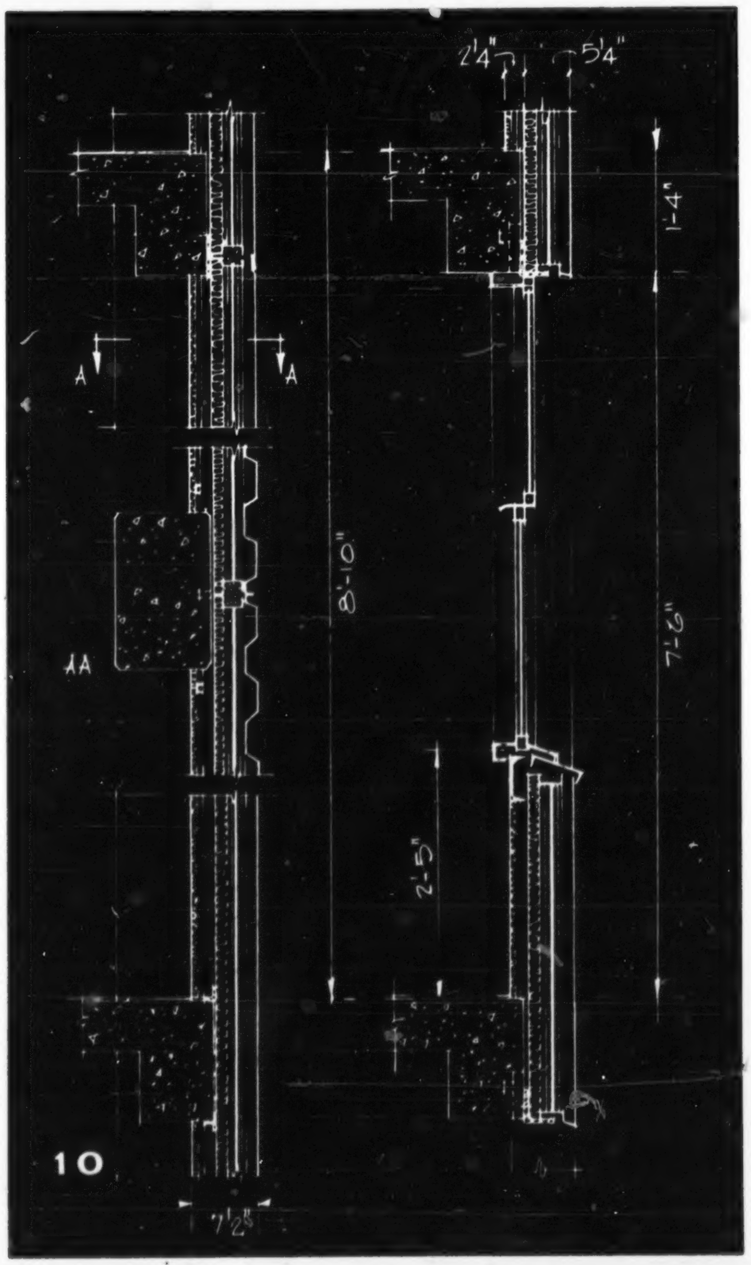
% of base: cost=**104.9**; U-value=**51.0**; thickness=**49.0**

R	Cost-per SF	Wall materials ▶
0.17	—	Outside surface
—	$ .50	20 ga. steel — vinyl coated & ribbed
0.70	.38	2½″ gypsum boards — cemented
—	.12	Center steel splines & edging channels — prorated
0.70	.38	2½″ gypsum boards cemented
—	.45	18 ga. metallic coated steel
5.55	.10	1½″ batt insulation
0.91	.21	¾″ channels & metal lath 3.4#
0.23	.28	¾″ plaster (3 coats)
—	.07	3 coats paint (oil base)
0.61	—	Inside surface
8.87	$2.49	
U=0.112	.40	Erection — prorated per SF
	$2.89	

% of base: cost=**109.8**; U-value=**46.4**; thickness=**58.8**

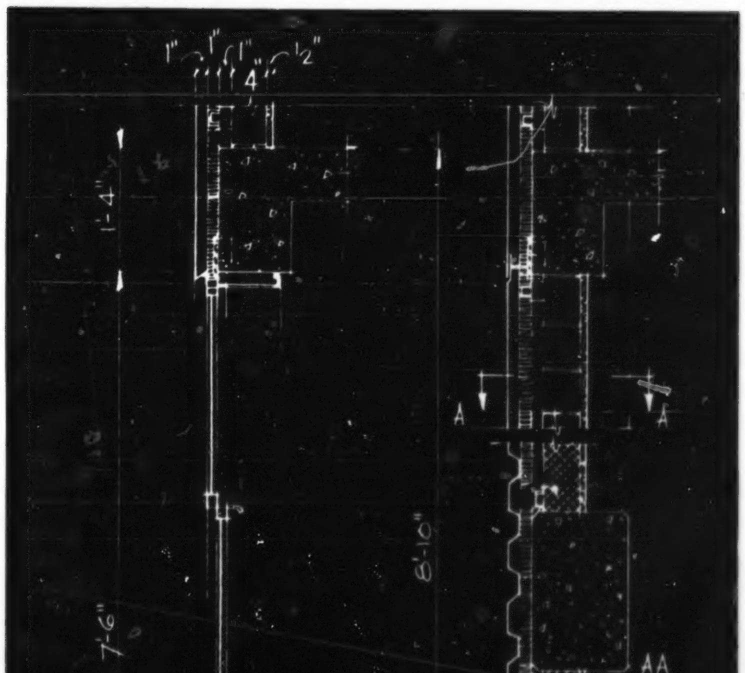
Panel Wall No. 3:

Panel-wall system completely assembled from currently available building products with an approved 2-hour fire rating and already erected as an uninsulated version and in use in New York City. Possible omission of plastering (combined, in this case, with a tolerance of "metallic factory look") and substitution of painted metal interior surface permits immediate erection of this exterior panel wall with an 8% reduction of "in-place" costs — this wall system also shown in detail (see details — this section).



Panel Wall No. 4:

Lightest panel-type wall system considered for public housing — easily and quickly erected without scaffolding, fireproofing backup applied from inside after exterior "skin" (with attached Styrofoam backup) is securely anchored. This economical wall system (admittingly to be used on exterior wall above accessible 1st and 2nd floor level) again permits easy combination with other panel systems and possible cost saving integration with completely preassembled window units.



R	Cost-per SF	Wall materials ▶
0.17	—	Outside surface
—	$ .45	24 ga. steel — vinyl coated-ribbed
0.91	.15	1" horizontal channels (tacked to steel)
—	.12	1" vertical channels
—	.15	Spec. clips & anchors
6.69	.39	3" cement-wood fiber block
0.23	.22	½" plaster (2 coats)
—	.07	3 coats paint (oil base)
0.61	—	Inside surface
8.51	$1.55	
U=0.112	.08	4" curb prorated per SF
	.25	Erection — prorated per SF
	$1.88	

% of base: cost=**96.5**; U-value=**59.7**; thickness=**56.8**

◀Wall materials	Cost-per SF	R
Outside surface	—	0.17
Alum. siding (ribbed) — .032"	$ .73	—
1" horizontal channels (tacked to alum.)	.15	—
1" Styrofoam	.17	4.00
Mastic coating inside	.08	—
¾" vertical channels	.12	0.91
Spec. clips and fasteners	.15	—
4" cinder concrete block	.60	1.00
½" plaster (2 coats)	.22	0.23
3 coats paint (oil base)	.07	—
Inside surface	—	0.61
	$2.29	6.92
Erection — prorated per SF	.25	U=0.144
	$2.54	

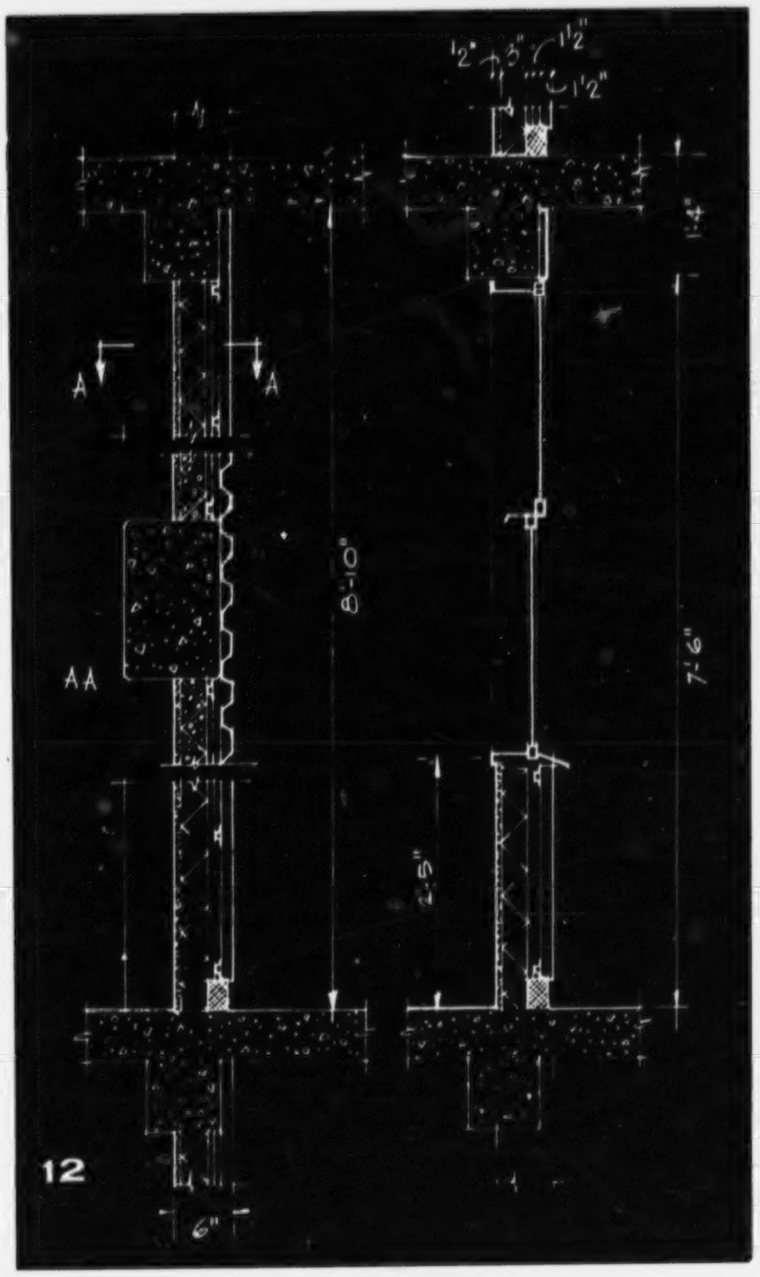
% of base: cost=**71.4**; U-value=**46.4**; thickness=**54.9**

ost-per SF	Wall materials ▶
—	Outside surface
$ .45	24 ga. steel — vinyl coated-ribbed
.15	1" horizontal channels (tacked to steel)
.12	1" vertical channels
.15	Spec. clips & anchors
.39	3" cement-wood fiber block
.22	½" plaster (2 coats)
.07	3 coats paint (oil base)
—	Inside surface
$1.55	
.08	4" curb prorated per SF
.25	Erection — prorated per SF
$1.88	

cost=**96.5**; U-value=**59.7**; thickness=**56.8**

rials	Cost-per SF	R
ice	—	0.17
(ribbed) — .032" channels to alum.)	$ .73	—
	.15	—
	.17	4.00
g inside	.08	—
channels	.12	0.91
nd fasteners	.15	—
ncrete block	.60	1.00
coats)	.22	0.23
(oil base)	.07	—
e	—	0.61
	$2.29	6.92
prorated per SF	.25	U=0.144
	$2.54	

cost=**71.4**; U-value=**46.4**; thickness=**54.9**



Panel Wall No. 5:
A non-fireproof panel-wall considered useful for further study — easily and economically erected (without scaffolding) in non-fireproof areas such as open corridors or combined with new construction techniques (see lift-slab section) which would provide required fireproofing as part of frame (slab cantilevered out beyond exterior wall); removing need for 2-hour fire rating and permitting use of a light-weight, insulated curtain wall erected between concrete slabs.

WALL NUMBER	WALL TYPE ①	COST PER SQ. FT. (SOLID WALL) ②	% ABOVE OR BELOW BASE WALL COST	U-VALUE	% REDUCTION OF U-VALUE OF 'S' WALL	SIZE OF WALL	% REDUCTION OF THICKNESS	SUGGESTED ALTERNATES ③	REVISED COST AS PER ALT. ②
	N.Y.S.D.H. 'STANDARD'	$2.63	—	0.241	— ④	12¾"	— ④		—
1	N.Y.S.D.H. 'STANDARD' MODIFIED	2.57	− 2.3	0.268	— ⑥	10¼"	20	ADD ONE COAT ASPHALTIC MASTIC AT .05 PER SQ. FT. (INSIDE FACE OF BLOCK)	$2.62
2 ◐	N.Y.S.D.H. 'STANDARD' INSULATED	2.92	+11.0	0.129	47	11½"	10	OMIT ¾" CHANNELS AND LATH AND ¾" PLASTER; ADD ONE EXTRA INCH OF RIGID FOAM & ½" PLASTER	2.83
3	'SCR' BRICK ⑦	2.77	+ 5.3	0.119	50	9½"	26	ADD RIGID INSULATION ON STRUCTURAL FRAME-COLUMNS AND BEAMS; PRORATED PER SQ. FT. ⑧	2.82
4	CAVITY WALL NO. 1—NO INSULATION	2.17	−17.5	0.106	56	9½"	26		—
5	CAVITY WALL NO. 2—LOOSE INSULATION	2.62	− 0.1	0.090	63	10½"	18		—
6	CAVITY WALL NO. 3—LOOSE INSULATION	2.57	− 2.3	0.092	62	10"	22		—
7 ◐	CAVITY WALL NO. 4—RIGID INSULATION ⑨	2.82	+ 7.2	0.092	62	10¾"	15	ALT. 1-OMIT 4" BLOCK AND ⑩ ADD 3" CEMENT-WOOD FIBER ALT. 2-OMIT 4" BLOCK AND ADD 4" CINDER BLOCK ⑪	2.61 2.29
8 ◐	PANEL WALL NO. 1—PRECAST CONCRETE ⑫	3.16	+20.1	0.091	62	7¼"	43	OMIT PLASTER AND ADD .10 FOR SMOOTH INSIDE FINISH	2.77
9	PANEL WALL NO. 2—STAINLESS STEEL AND CONCRETE ⑬	2.76	+ 4.9	0.123	49	6¼"	51	SUBSTITUTE PAPER-BACKED WIRE MESH FOR ¾" CHAN., SUBSTITUTE ½" PLASTER FOR ¾" PLASTER	2.64
10 ◐	PANEL WALL NO. 3—STAINLESS STEEL; GYPSUM BOARDS ⑭	2.89	+ 9.8	0.112	54	7½"	42	ALT. 1-OMIT ALL PLASTER; AND PAINT STEEL FACING ALT. 2-SUBSTITUTE ALUM. SIDING FOR COATED STEEL	2.40 3.17
11	PANEL WALL NO. 4—ALUM. & BLOCK	2.54	− 3.5	0.144	40	7¼"	43		—
12	PANEL WALL NO. 5—STEEL & BLOCK ⑮	1.88	−28.6	0.112	54	7"	45	SUBSTITUTE ALUM. SIDING FOR VINYL-COATED STEEL	2.14

◐ INDICATES WALL TYPES STUDIED IN NEXT SECTION; GRAPHIC COMPARISON OF COST (COL. 3), U-VALUE (COL. 5), SIZE

ITEMIZED CHART

SIZE OF WALL	% REDUCTION OF THICKNESS	SUGGESTED ALTERNATES ③	REVISED COST AS PER ALT. ②	WHICH IS UNDER BASE COST BY: ⑤	OR WHICH IS OVER BASE COST BY: ⑤	REVISED U-VALUE	REMARKS	WALL NUMBER
12¾"	— ④		—	—	—	—	USED AS STANDARD IN COMPARISON OF 12 WALLS	
10¼"	20	ADD ONE COAT ASPHALTIC MASTIC AT .05 PER SQ. FT. (INSIDE FACE OF BLOCK)	$2.62	$ .01	—	—	STANDARD WALL MODIFIED ONLY TO REDUCE WEIGHT AND THICKNESS	1
11½"	10	OMIT ¾" CHANNELS AND LATH AND ¾" PLASTER; ADD ONE EXTRA INCH OF RIGID FOAM & ½" PLASTER	2.83	—	$ .20	0.092	STANDARD WALL INSULATED WITH 1" & 2" FOAM; USED IN HEAT LOAD STUDY IN NEXT SECTION	2
9½"	26	ADD RIGID INSULATION ON STRUCTURAL FRAME-COLUMNS AND BEAMS; PRORATED PER SQ. FT. ⑧	2.82	—	.19	—	VERY FAST WALL TO ERECT, GOOD OVERALL STRENGTH; THINNEST MASONRY WALL	3
9½"	26		—	—	—	—	INEXPENSIVE, THIN, WELL INSULATED MASONRY WALL	4
10½"	18		—	—	—	—	EQUAL IN COST TO 'S' WALL; LOOSE FILL A PROBLEM	5
10"	22		—	—	—	—	EXPOSED CINDER BLOCK INSIDE REDUCES COST	6
10¾"	15	ALT. 1-OMIT 4" BLOCK AND ADD 3" CEMENT-WOOD FIBER ⑩ ALT. 2-OMIT 4" BLOCK AND ADD 4" CINDER BLOCK ⑪	2.61 2.29	.01 .34	— —	0.061 0.090	'CAVITY' FILLED WITH FOAM; HAS LOWEST U-VALUES; ALT. 2 IS INEXPENSIVE BEST INSULATED WALL	7
7¼"	43	OMIT PLASTER AND ADD .10 FOR SMOOTH INSIDE FINISH	2.77	.14	—	0.101	ADDITIONAL DETAILS SHOWN IN THIS SECTION	8
6¼"	51	SUBSTITUTE PAPER-BACKED WIRE MESH FOR ¾" CHAN., SUBSTITUTE ½" PLASTER FOR ¾" PLASTER	2.64	.01	—	0.139	WITH PAINTED PLASTER EQUALS PRESENT COST; U-VALUE REDUCED 43%; JOINTS NEED STUDY	9
7½"	42	ALT. 1-OMIT ALL PLASTER; AND PAINT STEEL FACING ALT. 2-SUBSTITUTE ALUM. SIDING FOR COATED STEEL	2.40 3.17	.23 —	— .54	0.123 —	ADDITIONAL DETAILS SHOWN IN THIS SECTION	10
7¼"	43		—	—	—	—	INEXPENSIVE PANEL TYPE; EASILY PREFABRICATED	11
7"	45	SUBSTITUTE ALUM. SIDING FOR VINYL-COATED STEEL	2.14	.49	—	—	USE OF VINYL-COATED STEELS NO LONGER EXPERIMENTAL	12

IC COMPARISON OF COST (COL. 3), U-VALUE (COL. 5), SIZE (COL. 7) ON NEXT CHART; FOOTNOTES 1-15 ON NEXT PAGE

2 Itemized Chart of Twelve Exterior Walls

Footnotes to itemized chart

1. See horizontal and vertical sections — same corresponding wall number.
2. "In-place," N.Y.C. area — March '58.
3. Refer to horizontal and vertical sections.
4. From % of cost, "U," and size — see tabulation under each wall section.
5. Refers to New York State Division of Housing "standard" wall used as base cost — col. 3.
6. Insulation not considered — only wall with plus; all others less than "standard."
7. 2" x 5½" x 11½" brick — developed by Structural Clay Products Institute.
8. Limited insulation of concrete frame.
9. Expanded polystyrene rigid foam — Styrofoam.
10. Insulrock or equal.
11. Epoxy resin paint.
12. Modification of Marietta panel.
13. Modification of Washington steel panel.
14. Modification of H. H. Robertson panel.
15. Does not have 2-hour fire rating.

At left the basic characteristics of the 12 wall types studied are itemized . . . on the following page this itemized information is presented for visual comparison. A complete study of the various wall types proposed indicates that no single exterior wall system can be selected which would meet all the basic requirements of public housing work as previously listed. A careful comparison and evaluation of each wall system and of the entire group prior to final selection is therefore necessary.

Prefabrication:

In a review of both the itemized chart and the comparative chart that follows some mention must be made of the basic qualities of some of the wall systems which cannot easily be shown in chart or graph form. Cost in place — size or thickness — ability (or inability) to insulate — all these basic qualities can be accurately calculated and presented for quick comparison — and indeed, careful study, analysis, review of costs and erection details and computations have been applied to some 40 wall systems made up of commercially available components before acceptance of the 12 wall systems presented in this section was completed. Those presented (with suggested alternate details) are structurally sound wall systems which should be acceptable to both an owner honestly searching for better ways to build and a contractor willing to help in that search. One outstanding feature of several wall systems proposed however, cannot be related in terms of money, inches, or comfort. This is the basic quality of 5 of the wall types to contribute to efficient, all-weather installation. A "panel-type" wall system (as yet not fully tested in public housing work) offers the following definite advantages:

Prefabricated in a shop; minimum field assembly
Large units; sections easily handled
Standardization of units
Clean, dry construction; erection in all weather
Minimum man-hours needed; fast construction schedule
Minimum scaffolding required
Structure easily closed-in
Minimum wall thickness; maximum insulation
Integrated window openings
Color and texture variation
Integral inside and outside finishes
Plastering omitted, if desired
Demountable and replaceable
Minimum fastening problems; minimum joint problems
Accepted construction method

These qualities, in addition to those listed at left and on the pages that follow make the panel wall systems a challenge that should be accepted and put to the test in the near future.

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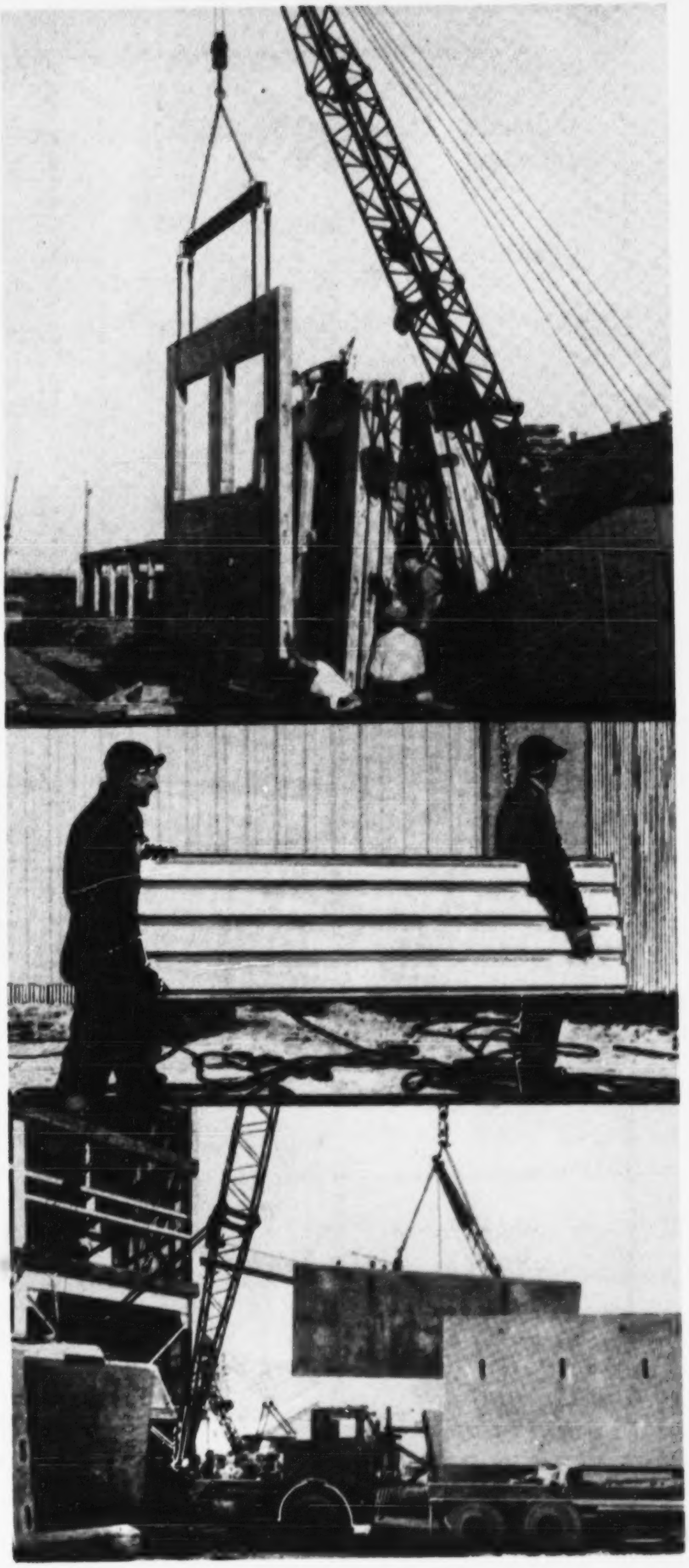
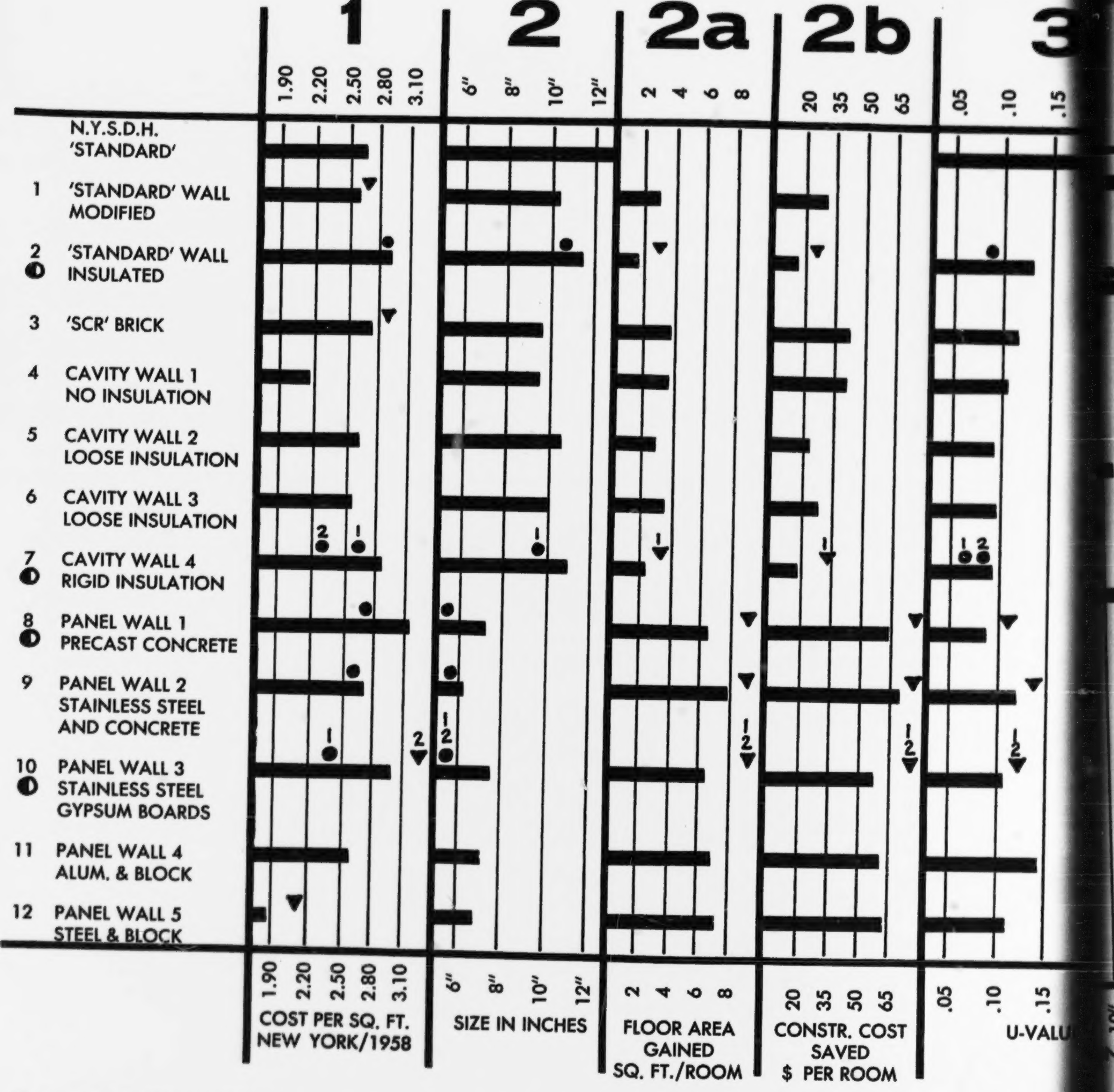
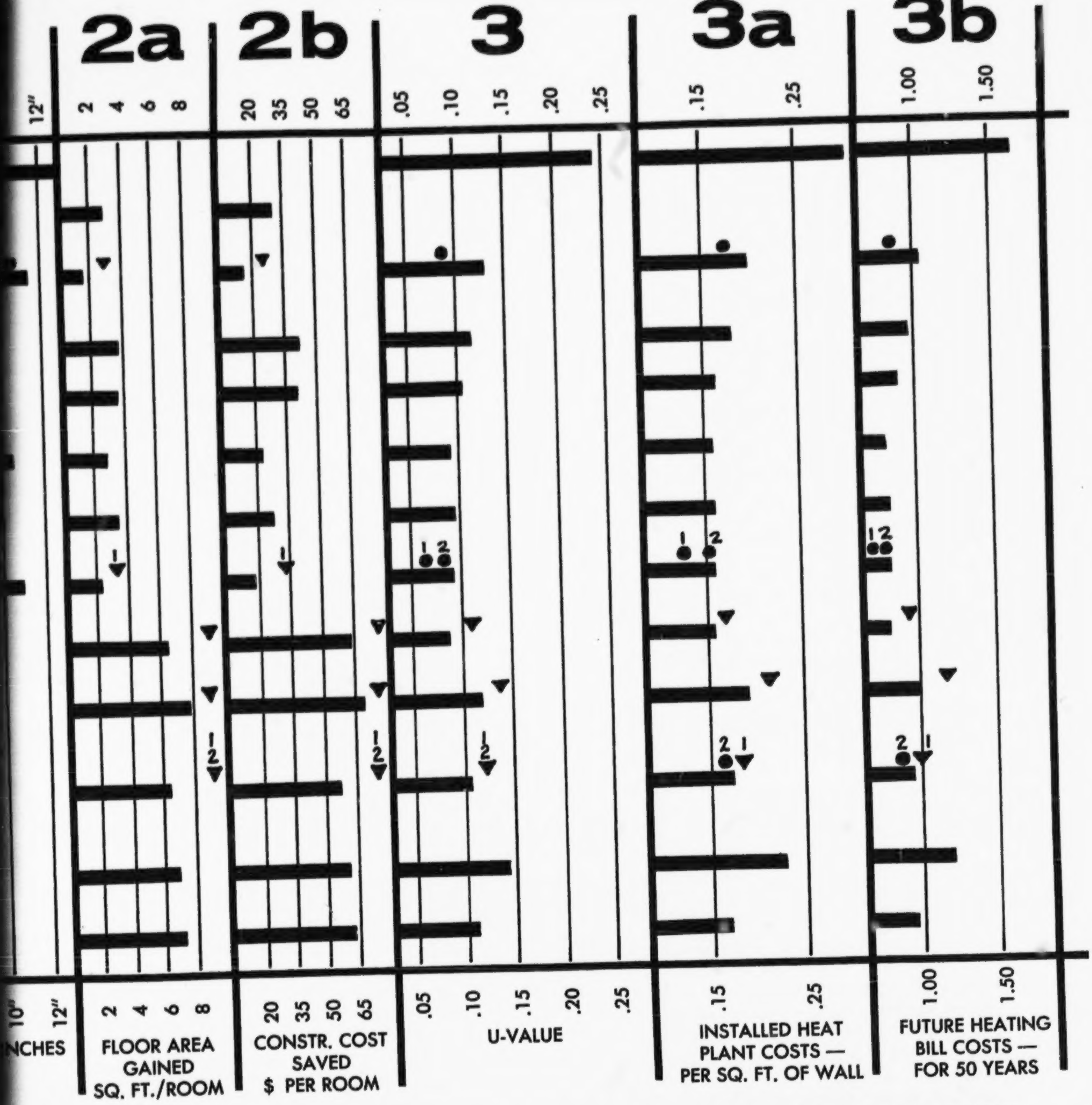




◐ INDICATES WALL TYPES STUDIED IN NEXT SECTION OF THIS CHAPTER; EACH COLUMN GIVES CALCULATED VA

▬ INDICATES WALL DATA FOR 12 EXTERIOR WALLS (PREVIOUS CHART); ▼ ABOVE BASIC VALUE AND ● BELOW BASIC

COMPARATIVE CHART



OF THIS CHAPTER; EACH COLUMN GIVES CALCULATED VALUES FOR ITEMS LISTED AS PER NOTES AT RIGHT
OUS CHART); ▼ ABOVE BASIC VALUE AND ● BELOW BASIC VALUE OF WALL DATA FOR SUGGESTED ALTERNATES

3 Comparative Chart of Twelve Walls

The graphic chart at left serves to summarize the advantages and deficiencies of the various wall systems proposed. All 12 have been compared to a fixed "standard" — in this case the present exterior wall in use on all public housing work in New York City. This wall is detailed at the beginning of this section and is further analyzed in terms of erection and heating costs in the following section. The various bars on the graph are intended to give average values for the subjects listed. The construction picture in New York fluctuates too much in place and time to permit calculation of exact values. The cost figures have been checked and are believed precise enough to give a clear picture of the following, reading each bar across from left to right:

Bar 1. Cost of the wall:

Bar indicates cost of one sq. ft. of wall (75% of exterior envelope; window area - 25% - omitted) — costs are total local prices, complete, in-place, and represent average values of cost data on each wall compiled from following sources consulted specifically for this research: N. Y. State Division of Housing
Seelye, Stevenson, Value & Knecht
Rheinstein Construction Co.
H. Nash Babcock

Bar 2. Wall thickness:

Bar indicates total thickness of each wall as per horizontal and vertical sections previously shown as well as revised thickness as per suggested alternates in previous itemized chart.

Bar 2a. Wall thickness:

Bar indicates gross floor area gained by reduced thickness of wall: added floor area gained per room if included in building — (Bar 2a.) and immediate construction saving if omitted — (Bar 2b.).

Gross square foot floor area gained per room by reduced wall thickness is based on floor area of typical housing project wing from housing project used as a standard throughout this report. This typical wing breaks down as follows:

39.5′ x 84.13′=3323 gross sq. ft.=area of wing.
Wall (12¾″ thick)=258 sq. ft. of above gross area.
4 apartments per wing (typical for this project) and
4.33 rooms per apartment (typical for this project).

Each room=3323/17.2=194 sq. ft. average area,
each room= 258/17.2= 15 sq. ft. average area
floor area taken by exterior wall per room;
thus average room=194−15=179 net area (usable).
Area gained (by walls thinner than 12¾″) is
compared to this net average floor area, and
Cost saved ($10.08 x area thus saved) is
compared to this net average floor area.

Area thus gained for total wing is shown as number of sq. ft. gained per each of 17 rooms if thinner exterior walls are used, holding exterior dimensions of typical wing constant.

Bar 2b. Wall thickness:

Bar indicates total cost of wing construction saved if extra floor area is omitted, based on construction costs per sq. ft. for typical housing project wing above:

Room area=(above) 194 sq. ft.
Total average cost=$1952.50
Construction cost=$10.08 per SF

Construction cost thus saved for total wing is shown as cost saved per room, reducing exterior dimensions of typical wing with thinner exterior walls.

Note: This cost saved as shown in Bar 2b is a theoretical figure. Sources consulted for this portion of the research work have indicated that this theoretical saving should be reduced by 30% to reflect net practical total.

Bar 3. Insulating value of wall

Bar indicates U-value for each wall system — calculated from R: thermal resistance as shown in sections — as per HVAC Guide, 1957. U equals BTU/HR./SQ. FT./DEG. F (outside & inside). Winter values used. U-values revised for alternate details.

Bar 3a. Insulating value of wall:

Bar indicates direct cost of total heating plant (installed) for one sq. ft. of wall in place. Window area omitted. All cost calculations (Bar 3a. & 3b.) as per heating study — second part of this Chapter.

Bar 3b. Insulating value of wall:

Bar indicates projected average cost of heating (operating) per Btu required by one sq. ft. of wall in place based on cost of supplying EDR (Equivalent

=3323/17.2=194 sq. ft. average area,
= 258/17.2= 15 sq. ft. average area
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Wall thickness:

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r area is omitted, based on construction
sq. ft. for typical housing project wing

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Insulating value of wall

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Insulating value of wall:

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r one sq. ft. of wall in place. Window area
All cost calculations (Bar 3a. & 3b.) as per
tudy — second part of this Chapter.

Insulating value of wall:

ates projected average cost of heating (op-
per Btu required by one sq. ft. of wall in
sed on cost of supplying EDR (Equivalent Direct Radiation) as required by wall section for 50 years. Source: New York City Housing Authority costs for '53-'54.

Note: Figures and data used for all 7 bars in graphic chart are itemized and explained further in part two of this Chapter.

As a guide towards final recommendation, two requirements originally proposed by the Division of Housing at the beginning of this research (see Introduction) are recalled:

Selection based on immediate savings:
Undoubtedly the present "standard" wall can be improved. This has been indicated by the data and charts of this study and brought out in dozens of interviews with architects, engineers, and contractors.

1. **Modify it** — reduce its thickness by use of 4" backup block and save 6 cents on the present wall. Save, in addition, on reduced width of expensive 16 and 18 gage steel window trim and enclosures as wall is modified closer to window width of 3" to 4". Higher U-value easily covered by present 10% to 20% factors applied to heating design (requiring no increase in heat plant costs) — see second part of this Chapter.
2. **Insulate it** — above all insulate — for immediate and future savings in wall, heating plant, and fuel. Experiment with rigid and loose insulation on the present wall until the right combination is arrived at: in cost (present and future), in speed and ease of erection, in labor and union acceptance, in savings to owner and comfort to tenant. Wise selection of insulation and outside facings can result in wall savings of 1c to 53c per sq. ft. of net (solid) wall in place.

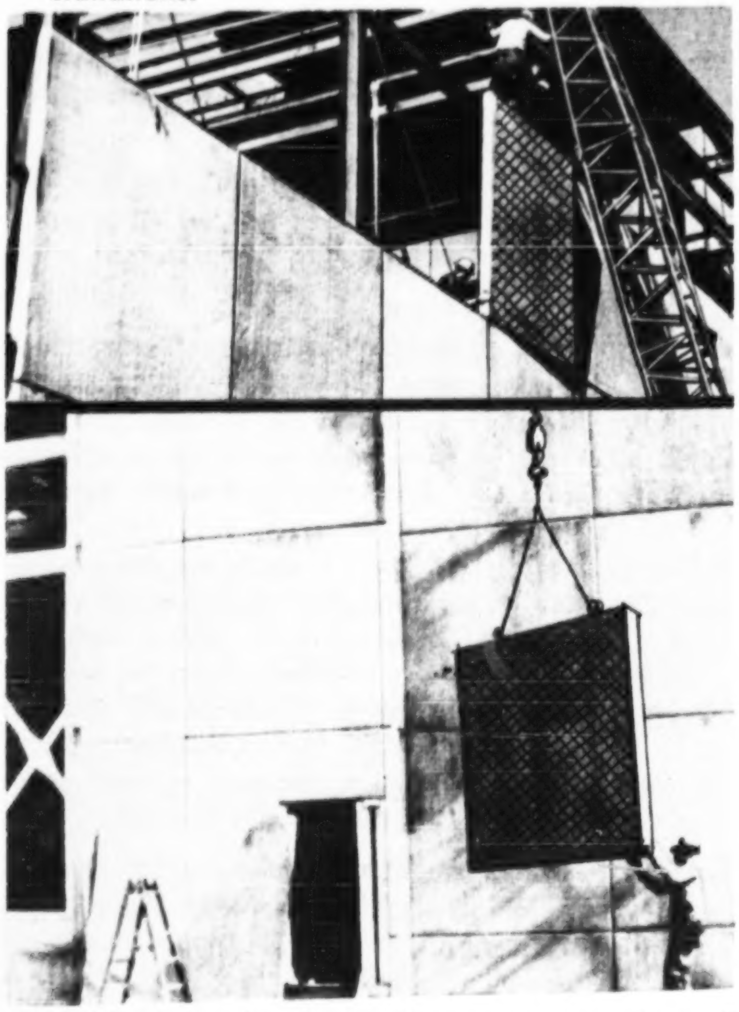
Plan ahead for possible future savings:

Savings in the very near future can and will be realized when the Division of Housing accepts, tests and uses a panel-type (concrete or metal faced) wall system which will permit quicker enclosure of the skeleton than the present masonry wall. At that time many of the cost savings itemized and inferred in the study of the panels in this section can be verified. Towards that end, two systems were selected for recommendation for use on a trial basis and for additional detailing on the following pages.

4

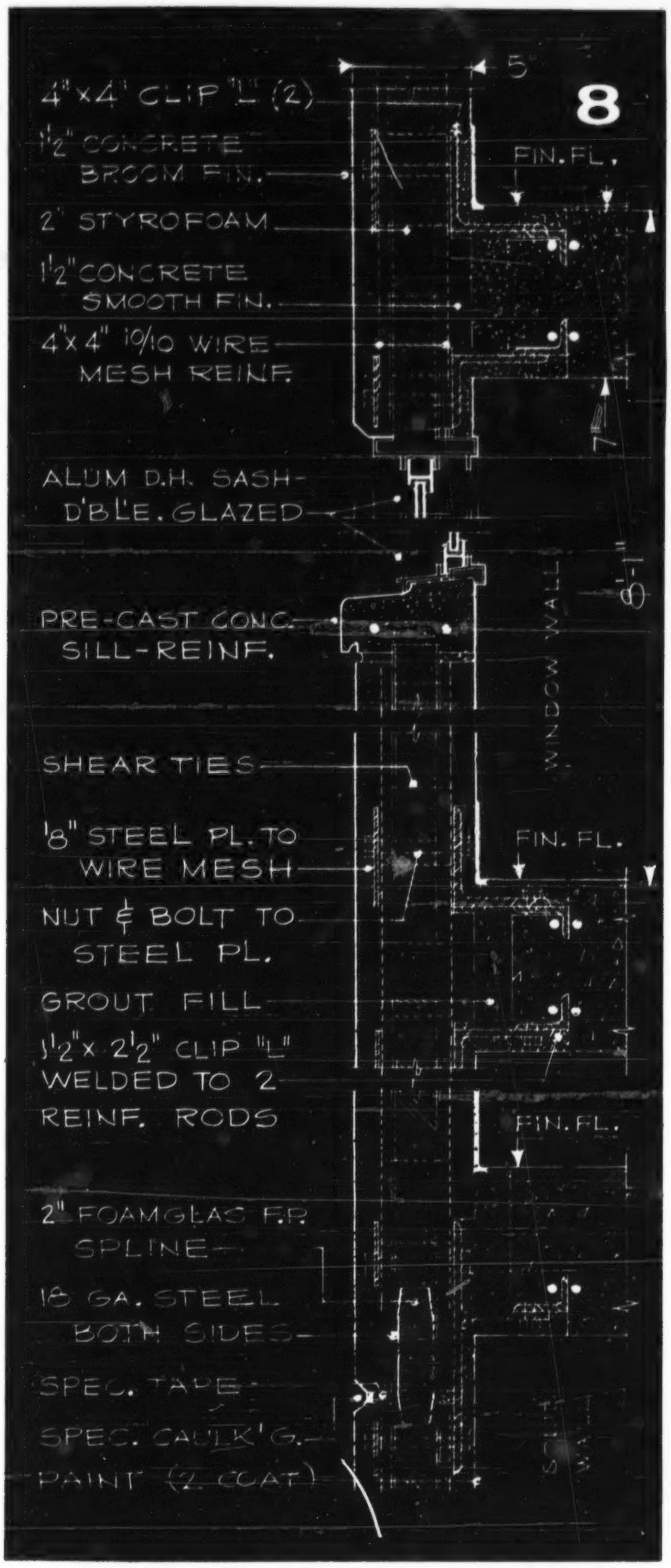
Discussion and Detail of Two Prefabricated Walls

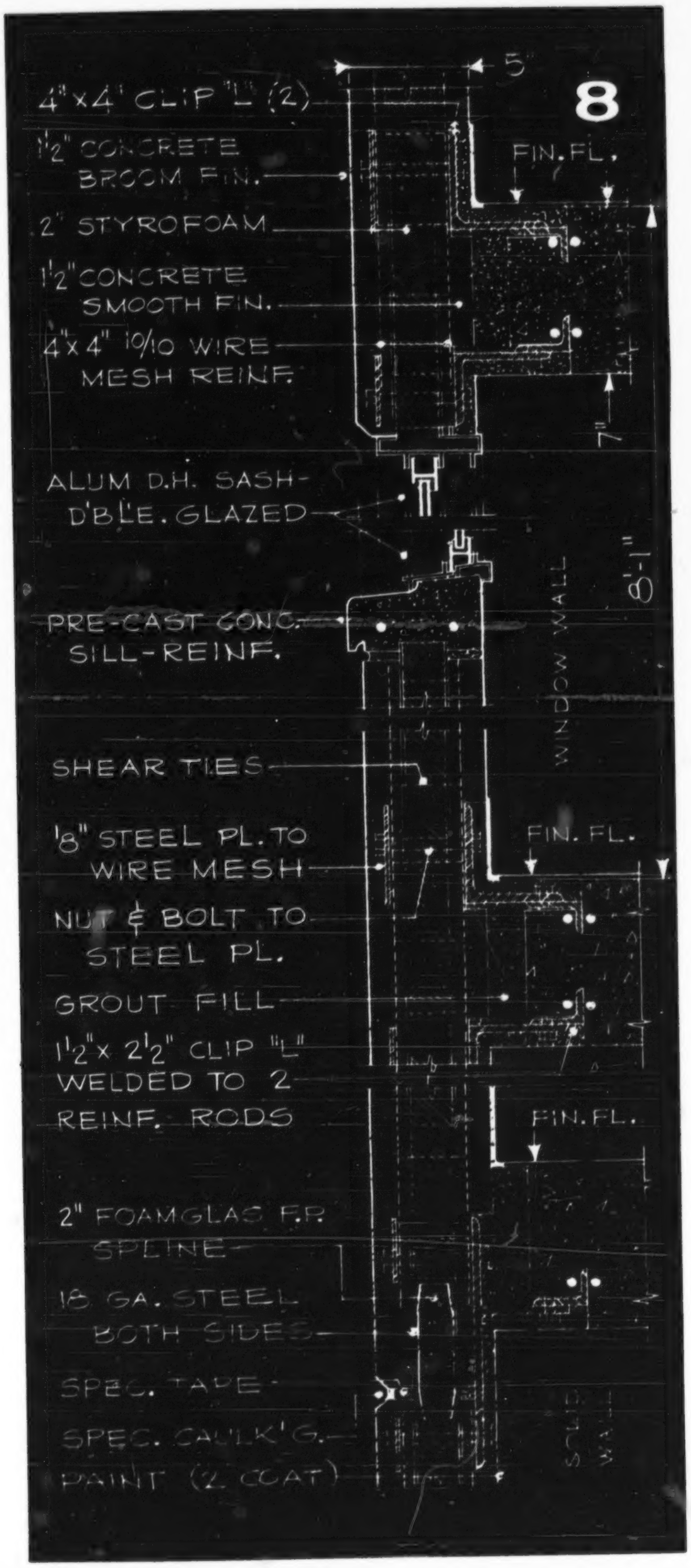
1. Precast concrete wall panel — commercially available in New York City, proven in many installations.



A modification of a basic 5" precast concrete wall panel developed by the Marietta Concrete Corp. of Ohio. In addition to advantages already mentioned for panel-type wall systems, this one has the added benefits of being a completely detailed and tested system, used throughout New York area, competitively priced, represented directly in New York with local branch office and distributors; having 2-hour fire rating; and having approval of New York State for industrial buildings. Typical details presented on this page — typical elevation studies with exterior wall No. 10 presented on center page.

This wall developed by the research group with the cooperation of representatives of the Marietta Concrete Corp. — New York City office, the Dow Chemical Company — New York City office, and Mr. Philip M. Grennan of the office of Alfred E. Poor.


8
5"
4"x4" CLIP "L" (2)
1½" CONCRETE BROOM FIN.
2" STYROFOAM
1½" CONCRETE SMOOTH FIN.
4"x4" 10/10 WIRE MESH REINF.
ALUM D.H. SASH- D'BL'E. GLAZED
PRE-CAST CONC. SILL-REINF.
SHEAR TIES
⅛" STEEL PL. TO WIRE MESH
NUT & BOLT TO STEEL PL.
GROUT FILL
1½"x 2½" CLIP "L" WELDED TO 2 REINF. RODS
2" FOAMGLAS F.P. SPLINE
18 GA. STEEL BOTH SIDES
SPEC. TAPE
SPEC. CAULK'G.
PAINT (2 COAT)
FIN. FL.
FIN. FL.
FIN. FL.
7"
8'-1"
WINDOW WALL


8
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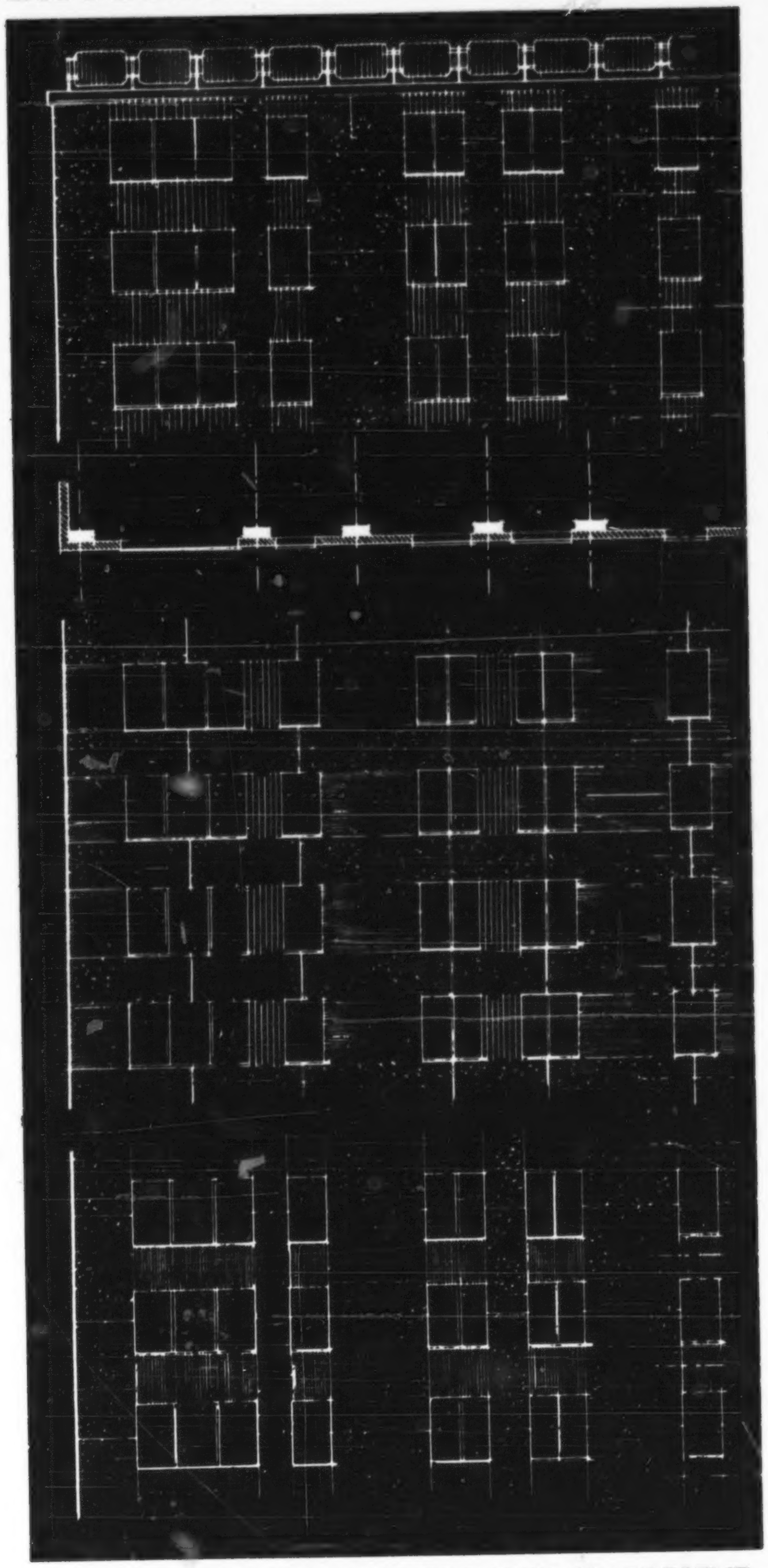
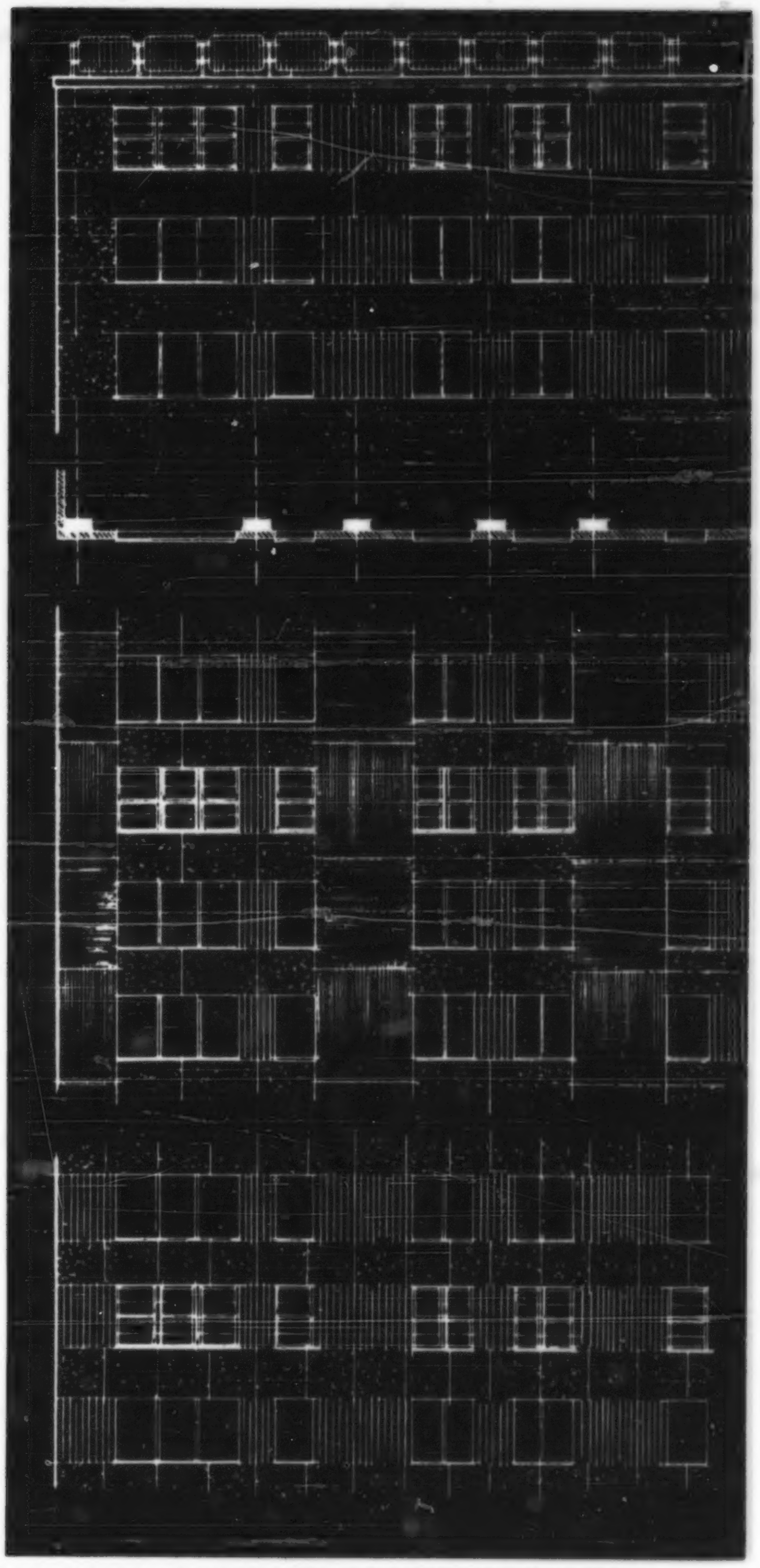
NUT & BOLT TO STEEL PL.
GROUT FILL
1½"x 2½" CLIP "L" WELDED TO 2 REINF. RODS
FIN. FL.
2" FOAMGLAS F.P. SPLINE
18 GA. STEEL BOTH SIDES
SPEC. TAPE
SPEC. CAULK'G.
PAINT (2 COAT)
SOLID WALL

EXTERIOR WALL NO. 8:

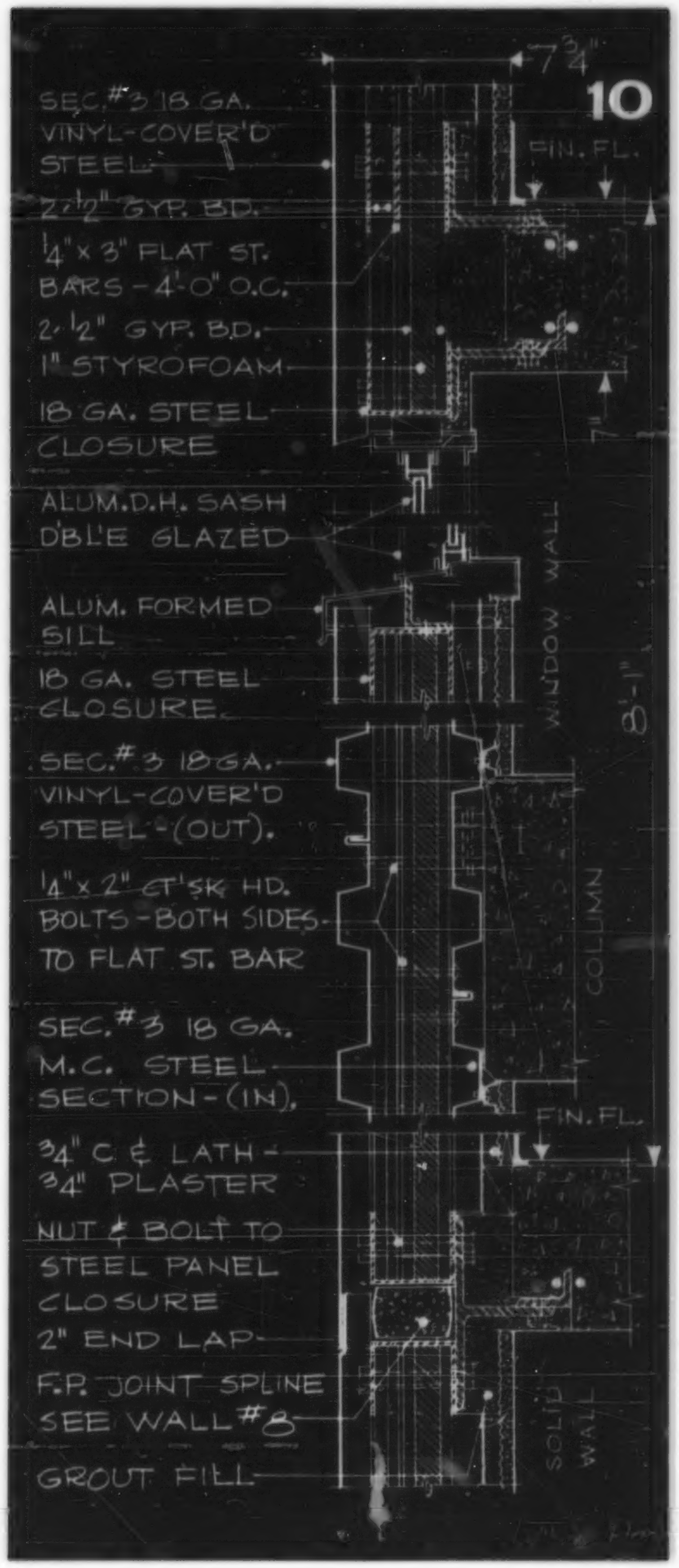


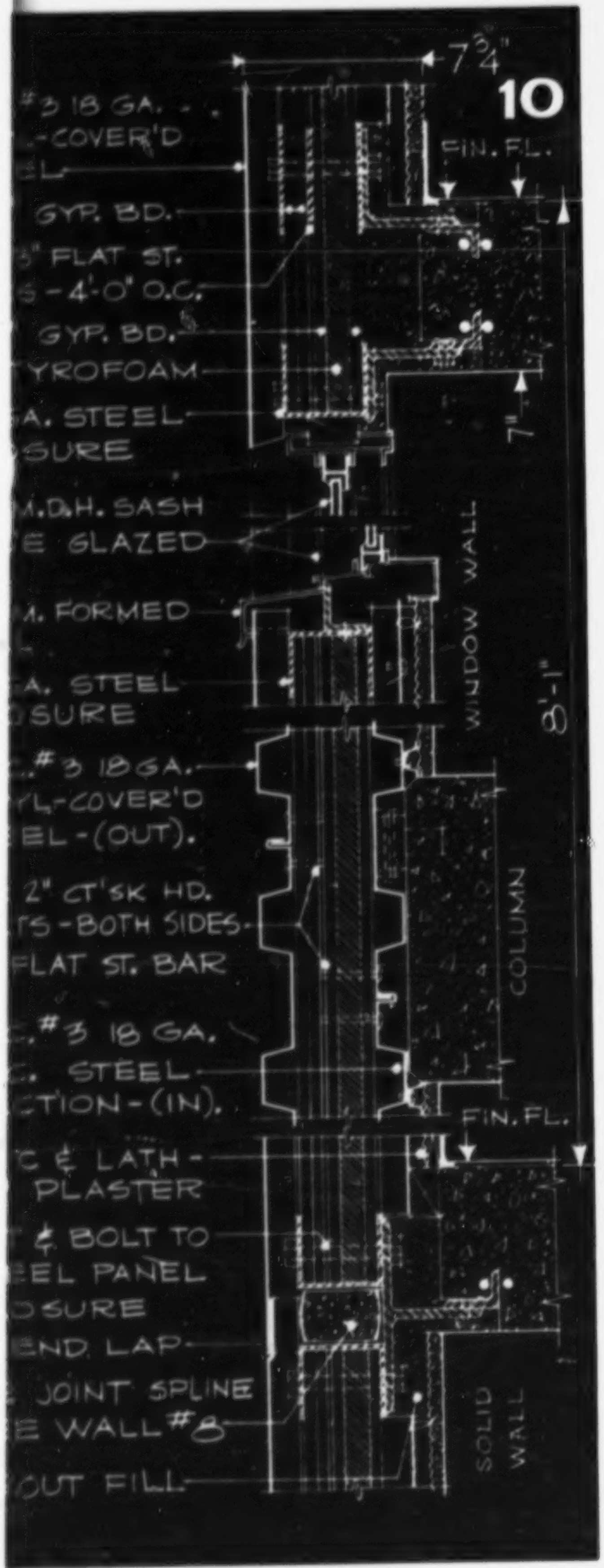
SIX ELEVATION STUDIES BASED ON PRESENT WINDOW ARRANGEMENT AND STRUCTURAL FRAME DIMENSIONS OF TYPICAL BUILDING

EXTERIOR WALL NO. 10:

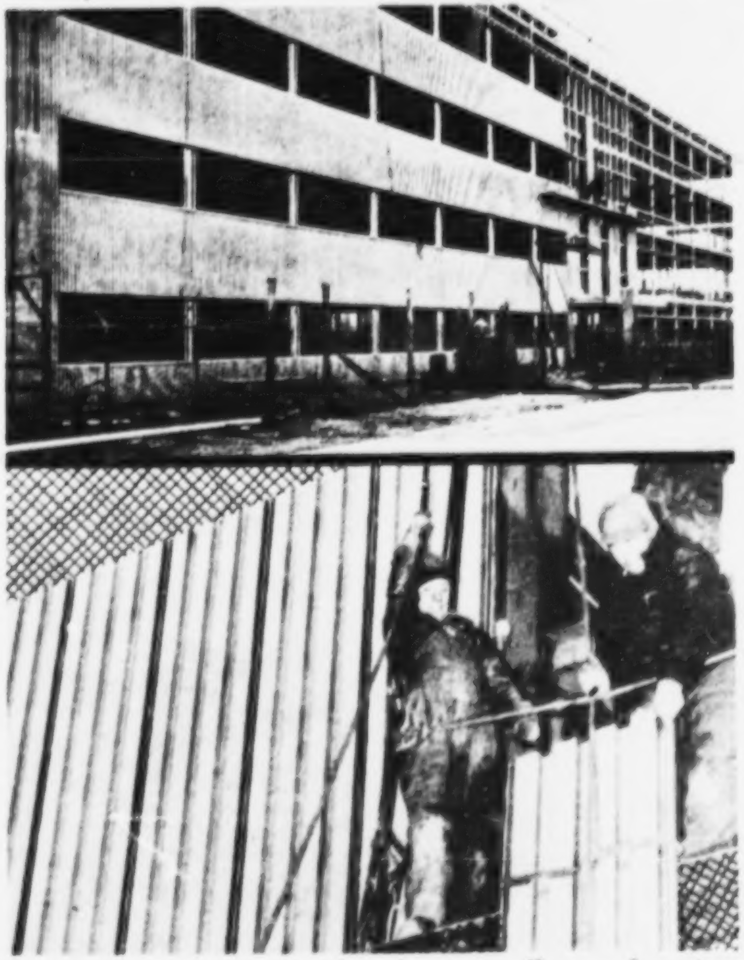


WALL NO. 8 AND NO. 10 USED IN VARIOUS COMBINATIONS WITH WINDOW OPENINGS ON A TYPICAL N.Y.C. HOUSING PROJECT


10
7 3/4"
SEC. #3 18 GA. VINYL-COVER'D STEEL
2-1/2" GYP. BD.
1/4" x 3" FLAT ST. BARS - 4'-0" O.C.
2-1/2" GYP. BD.
1" STYROFOAM
18 GA. STEEL CLOSURE
ALUM. D.H. SASH DBL'E GLAZED
ALUM. FORMED SILL
18 GA. STEEL CLOSURE
SEC. #3 18 GA. VINYL-COVER'D STEEL - (OUT).
1/4" x 2" CT'SK HD. BOLTS - BOTH SIDES - TO FLAT ST. BAR
SEC. #3 18 GA. M.C. STEEL SECTION - (IN).
3/4" C & LATH - 3/4" PLASTER
NUT & BOLT TO STEEL PANEL CLOSURE
2" END LAP
F.P. JOINT SPLINE SEE WALL #8
GROUT FILL
FIN. FL.
WINDOW WALL
COLUMN
8'-1"
FIN. FL.
SOLID WALL


10
7 3/4"
#3 18 GA.
-COVER'D
EL
GYP. BD.
3" FLAT ST.
S-4'-0" O.C.
GYP. BD.
YROFOAM
A. STEEL
SURE
M.D.H. SASH
E GLAZED
M. FORMED
A. STEEL
SURE
#3 18 GA.
YL-COVER'D
EL-(OUT).
2" CT'SK HD.
TS-BOTH SIDES
FLAT ST. BAR
#3 18 GA.
C. STEEL
CTION-(IN).
C & LATH
PLASTER
T & BOLT TO
EEL PANEL
SURE
END LAP
JOINT SPLINE
E WALL #8
OUT FILL
FIN. FL.
7"
8'-1"
WINDOW WALL
COLUMN
FIN. FL.
SOLID WALL

2. Preformed steel and gypsum-board "sandwich type" wall panel — already erected in New York City.



An insulated version of a basic wall panel system developed by H. H. Robertson Co. and successfully installed in portions of Bellevue Hospital in New York City; has code approval as a 2-hour wall. Outside face available in a large variety of materials — stainless steel, aluminum, vinyl-coated steels, porcelain enamelled aluminum. Inside face can be furred and plastered (as shown) or can be painted direct as a finished face. Typical details are presented on this page — typical elevation studies combined with exterior wall No. 8, shown as if erected on standard public housing structural frame, and presented on center page.

This wall developed by the research group with the cooperation of representatives of the H. H. Robertson Company — New York City office, the Dow Chemical Company — New York City office, and Mr. Wayne F. Koppes, architectural consultant.

5 Insulation Methods for the Exterior Wall

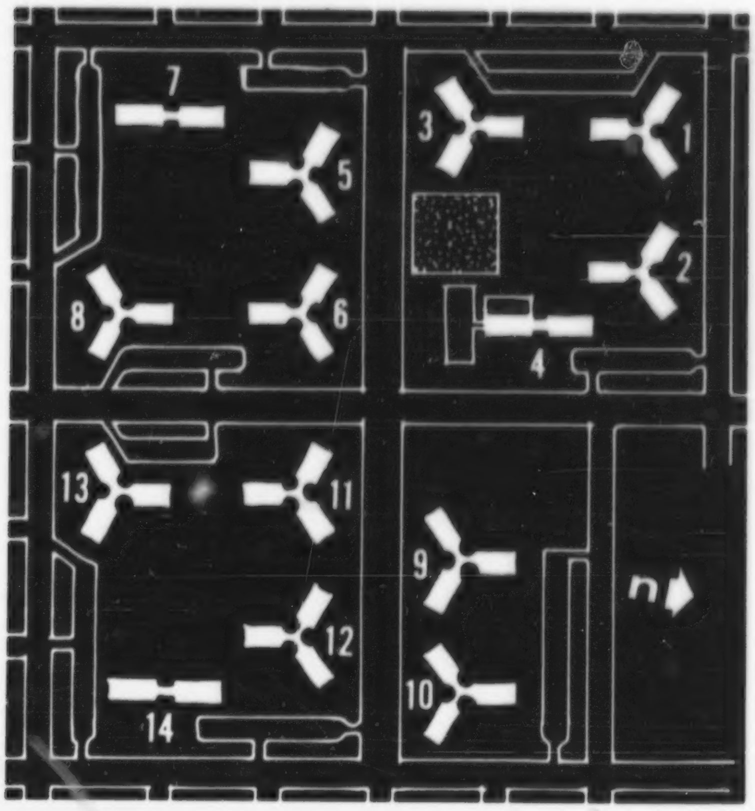
This section of the study of the exterior wall will examine the savings possible by insulating the present wall (Wall No. 2 or a modified version of Wall No. 2), a "redesigned" present wall (Wall No. 7) and the two recommended panel wall systems (Wall No. 8 and No. 10), in order to reduce overall construction costs by reducing the initial heating plant cost (immediate) and to reduce the costs of operating the heating plan (future). This study is based on details and costs as presented in the first part of this Chapter.

No study of the possible ways of reducing the cost of the exterior wall — either in unit cost of its components or in erection costs — can be complete without tying this study in with an examination of the insulating qualities of that wall. This, of course, includes not only the insulating properties of the solid wall but also those of the window wall. Good insulation (properly applied) will pay dividends for its small, initial extra cost in two ways: by providing a comfortable interior climate winter and summer (allowing maximum use of that room) and by reducing heating plant costs, both first cost and operating costs. This study assumes that the former quality will be an added benefit gained in taking advantage of the cost saving benefits of the latter. The basic problem is simply:

Does it pay to insulate?

It is costlier to insulate a wall. That extra cost must be recovered in public housing work to be justified. This justification will take the form of a complete examination of the heating requirements of an average housing project wing, relying only on calculated facts and figures from quoted sources for its proof. It must be repeated that in this study average areas and related figures are used throughout since exact figures (based on a definitive study of an actual test case — strongly recommended by many to establish the "true" validity of insulation) are impossible to come by until such a test is conducted in the field.

First: The study of a "typical housing project" wing (costs, physical properties, heat requirements, etc.) to lead **second**: to establishment of an "average apartment room" of that project which will in turn serve as a "measuring rod" for **third**: a "comparative cost study" of insulating the present exterior wall with its 2 alternate modifications (Wall No. 2 and No. 7) and the two recommended wall systems (Wall No. 8 and No. 10).



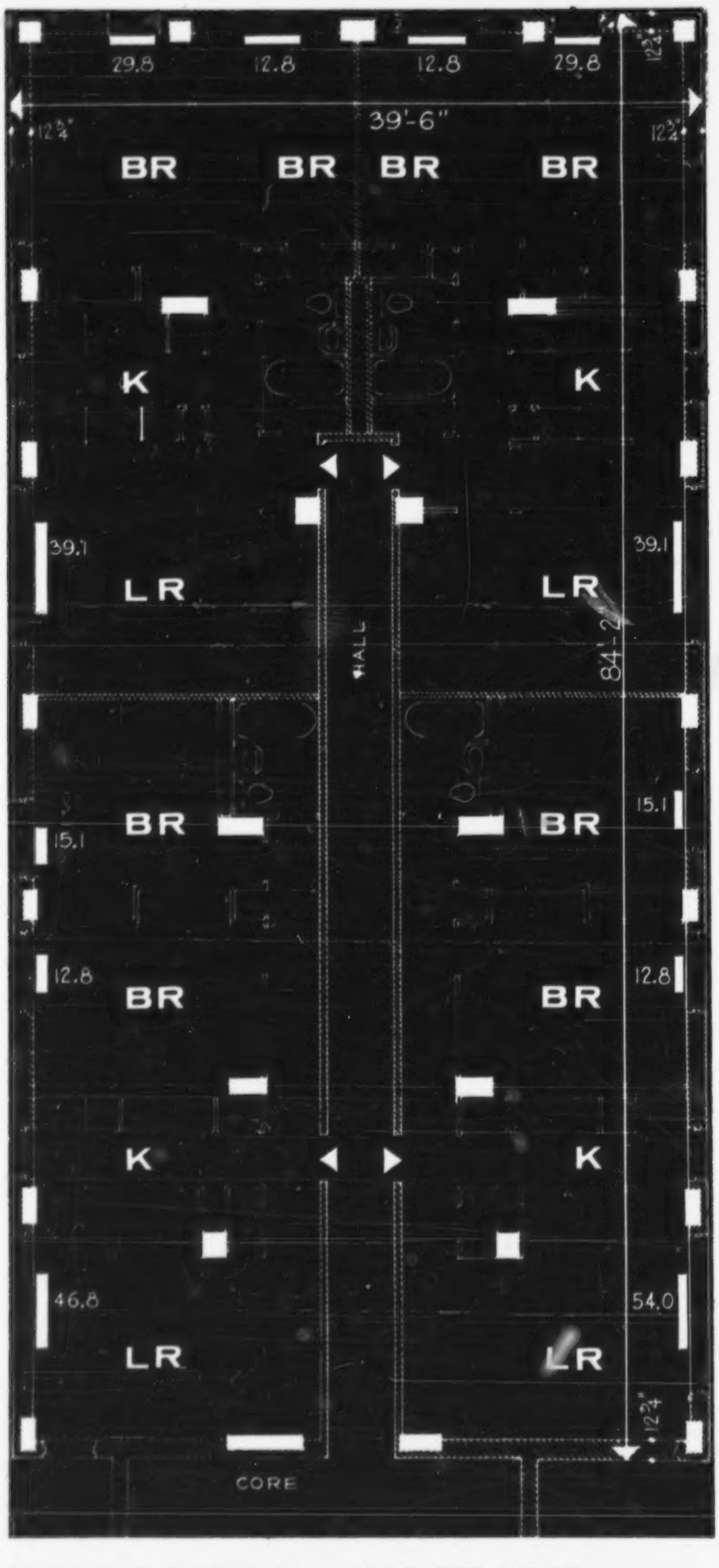
SITE PLAN OF PROJECT UNDER STUDY

A Typical Housing Project:

Location: The Bronx, New York City.
Presently under construction.
New York City construction firm.
Bid during Summer, 1957
Contract awarded: late Fall, 1957
Joint New York State Division of Housing and
New York City Housing Authority project.

11-12 story & 3-20 story buildings
12 story: 3 wings with central core
20 story: 2 wings with central core
Reinforced concrete structures on piles
Exterior wall: first part of this Chapter
Total construction rooms: 8761
Total apartments: 2025
Average rooms per apartment: 4.33
Net housing area: 40.36 acres
Total building coverage: 4.05 acres (9.8% of land)
Density: 219 persons/acre
Total area—2,138,666 SF
Total cubage—19,247,987 CF
Floor-to-floor height: 8′-7″ above 1st.
Total contract—$21,556,064
Cost per cubic foot—$1.12
Cost per square foot—$10.08 (of floor area):
(using cube cost $1.12 x 9′-0″—floor-to-floor)
Heating & ventilating—$1,378,000
Cost per cubic foot—$0.0716 total H. & V. of which 12% for ventilation = $165,360
Cost per cubic foot = $0.0086 (Ventilating)
Net heating cost—$1,212,640 or
Cost per cubic foot = $0.0630 (Heating)
Heat plant cost per square foot—$0.567 (of floor area):
(using cube cost $0.0630 x 9′-0″ (floor-to-floor)

The above facts and figures from examination of complete contract drawings and from data published by New York City Housing Authority. Given above to establish scope and scale of housing project (see site plan - this page) — total contract for this project somewhat above average but all cube and sq. ft. costs (upon examination of 8 additional '57/'58 housing projects) are average.

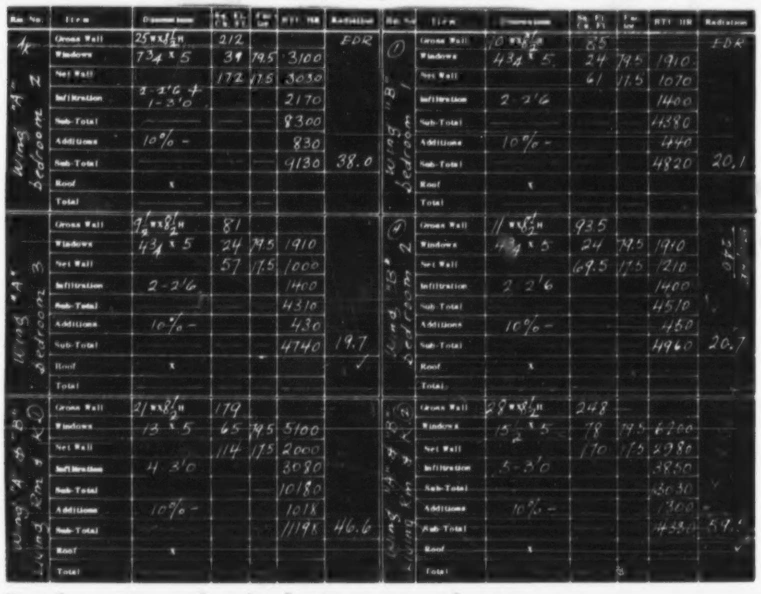


TYPICAL FLOOR PLAN — PROJECT WING
TOTAL RADIATION: 321 EDR

Project has 39 wings; 14 center cores;
roofs & 14 cores omitted in heat plant study
(average 3% to 4% total load)
roofs & cores included in heat bill study
(prorated per cube & sq. ft. per room above)

Gross floor area: 3323 sq. ft., each wing
Gross wall area — ext. wall (12¾" thick x 8'-7" high):
247.36' x 8.57' = 2122 sq. ft., each wing
Window area—26% of gross wall:
2122 x .26 = 552 sq. ft., each wing
Net (solid) wall area—74% of gross:
2122 x .74 = 1570 sq. ft., each wing
4 apart. @ 4.33 rm./apartment
Total of 17.2 rooms for each wing (average)
Average room—3323/17.2 = 193.7 sq. ft.
Heat load for typical project wing:
321 EDR (from plan); calculated as follows:

TYPICAL CALCULATION PAGE



Rm. No.	Item	Dimensions	Sq. Ft. Cu. Ft.	Factor	BTU HR	Radiation
4K Wing "A" bedroom 2	Gross Wall	25 W x 8½ H	212			EDR
	Windows	7¾ x 5	39	79.5	3100	
	Net Wall		172	17.5	3030	
	Infiltration	2-2'6 + 1-3'0			2170	
	Sub-Total				8300	
	Additions	10% -			830	
	Sub-Total				9130	38.0
	Roof	x				
	Total					
Wing "A" bedroom 3	Gross Wall	9½ W x 8½ H	81			
	Windows	4¾ x 5	24	79.5	1910	
	Net Wall		57	17.5	1000	
	Infiltration	2-2'6			1400	
	Sub-Total				4310	
	Additions	10% -			430	
	Sub-Total				4740	19.7
	Roof	x				✓
	Total					
Wing "A" & "B" Living Rm & K.D.	Gross Wall	21 W x 8½ H	179			
	Windows	13 x 5	65	79.5	5100	
	Net Wall		114	17.5	2000	
	Infiltration	4-3'0			3080	
	Sub-Total				10180	
	Additions	10% -			1018	
	Sub-Total				11198	46.6
	Roof	x				
	Total					

Rm. No.	Item	Dimensions	Sq. Ft. Cu. Ft.	Factor	BTU HR	Radiation
① Wing "B" bedroom 1	Gross Wall	10 W x 8½ H	85			EDR
	Windows	4¾ x 5	24	79.5	1910	
	Net Wall		61	17.5	1070	
	Infiltration	2-2'6			1400	
	Sub-Total				4380	
	Additions	10% -			440	
	Sub-Total				4820	20.1
	Roof	x				
	Total					
④ Wing "B" bedroom 2	Gross Wall	11 W x 8½ H	93.5			
	Windows	4¾ x 5	24	79.5	1910	
	Net Wall		69.5	17.5	1210	
	Infiltration	2-2'6			1400	
	Sub-Total				4510	
	Additions	10% -			450	
	Sub-Total				4960	20.7
	Roof	x				
	Total					
② Wing "A" & "B" Living Rm & K.	Gross Wall	28 W x 8½ H	248			
	Windows	15½ x 5	78	79.5	6200	
	Net Wall		170	17.5	2980	
	Infiltration	5-3'0			3850	
	Sub-Total				13030	
	Additions	10% -			1300	
	Sub-Total				14330	59.[illegible]
	Roof	x				✓
	Total					

Explanation of calculation page factors:
Design temp. = 0°-70° F.
EDR = Btu/hr ÷ 240
window = "U" x 70° F. = 1.13 x 70° = 79.5 Btu/hr
wall = "U" x 70° F. = .25 x 70° = 17.5 Btu/hr

Infiltration taken as follows:
@ window 2'-6" x 5'-0" = 710 Btu/hr
@ window 3'-0" x 5'-0" = 770 Btu/hr

10% added to total of each room, and then
20% added to total of each floor (not shown above)
BTU/hr ÷ 240 = total EDR per rm.
Total radiation as noted on plan at left
EDR breakdown listed on typical floor plan

INSULATION METHODS

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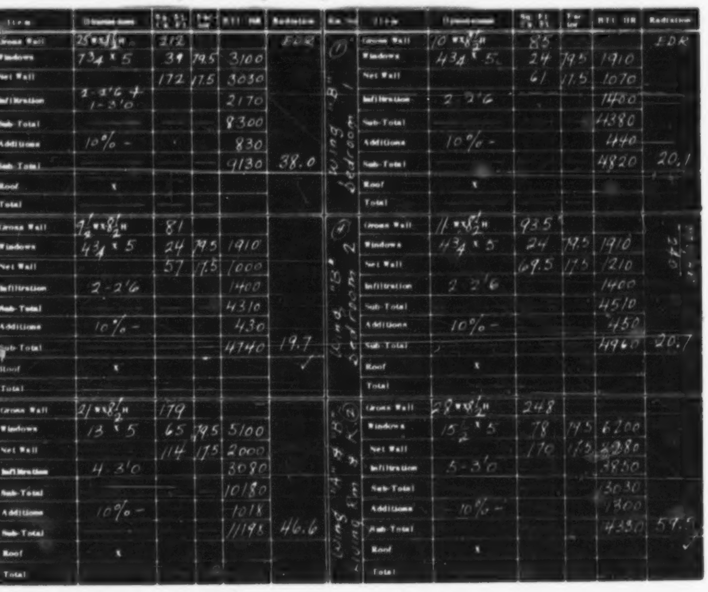

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	Net Wall		61	17.5	1070	
	Infiltration	2-2'6			1400	
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	Sub-Total				4510	
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R breakdown listed on typical floor plan

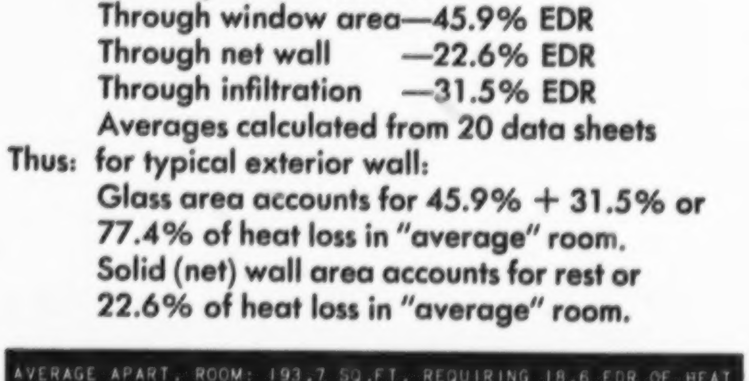
From typical calculation page and floor plan at left:
Total heat loss assumed through wall
Excludes loss through roof (small %)
Excludes loss through core (small %)
Assumes average window — 5'-0" x 6'-0"
Thus: Heat plant cost: related to wall/room
Heating cost: related to wall/room
Heat required by average room:
321 EDR/17.2 rooms = 18.6 EDR/room
Heated rooms face outside gross wall and
Gross wall of average room:
2122 sq. ft./17.2 = 123.4 sq. ft. per room

All of the above information obtained in reviews of project drawings with architects and mechanical engineers. Assumption that total heat loss of typical wing (other than top floor) is through exterior wall found entirely reasonable. However, two factors must be mentioned to complete this part of the picture. Total EDR listed (on floor plan) do not take into account 20% additional heat load automatically added by most mechanical engineering firms to total for pipe loss, boiler loss, stack loss, leakage, etc. Nor would it be correct to assume that a reduction of heat load requirements (through such means as wall insulation, double glazing, etc.) be directly proportional to a similar drop in total heating requirements (i.e. boilers, burners, etc., are made in stepped capacity ratings and not all exact boiler, pipe, and heating element capacities are commercially available). But the reductions are real and must be credited against the initial cost of the insulation.

The first factor seems to suggest that some saving in heat plant costs would immediately occur by paying mechanical engineers a larger fee to calculate more closely and precisely all heat losses for public housing projects. The second factor suggests that heat plant costs (immediate) and fuel costs (future) should not be reduced in direct proportion to percent reduction of heat loss of any wall studied in this report. The first suggestion is endorsed and the second is carried out in the rest of this study of heat plant and fuel costs.

Average Apartment Room:

Average room has 123.4 sq. ft. of exterior wall
Average room requires 18.6 EDR of heat
Of 123.4 sq. ft. gross wall:
26% window = 32.1 sq. ft. (from drawings)
74% net (solid) = 91.3 sq. ft. (from drawings)
Review of typical EDR requirements
(refer to copy of data page) shows:
% of 3 possible heat losses:
Through window area—45.9% EDR
Through net wall —22.6% EDR
Through infiltration —31.5% EDR
Averages calculated from 20 data sheets
Thus: for typical exterior wall:
Glass area accounts for 45.9% + 31.5% or 77.4% of heat loss in "average" room.
Solid (net) wall area accounts for rest or 22.6% of heat loss in "average" room.


AVERAGE APART. ROOM: 193.7 SQ.FT. REQUIRING 18.6 EDR OF HEAT
AVERAGE GROSS WALL (EXTERIOR)= 123.4 SQ. FT.
22.6%
77.4%
NET WALL= 74% OF WALL OR 91.3 SQ.FT. AND ACCOUNTS FOR 22.6%
WINDOW = 26% OF WALL OR 32.1 SQ.FT. AND ACCOUNTS FOR 77.4%

Portion of installed heat plant costs:
193.7 sq. ft. x $0.567 per sq. ft. = $119.83
Cost of heating average room per year:
$12.72 (NYCHA: average for '53/'54)

Thus for average apartment room:
$119.83 heating plant cost ÷ by 18.6 EDR = $6.44
(heating plant costs, installed).
$12.72 heating costs ÷ by 18.6 EDR = $0.68
(heating bill for one year).

Note: at this point a quick check can be made of the validity of the assumptions made (and therefore of the average figures proposed):
Total heating contract divided by unit cost of required EDR should equal total EDR required.
$1,212,640 ÷ $6.44 = 190,000 EDR
This proves to be about 5%
under total calculated
EDR for this project (200,000).
Thus: the average cost of $6.44 of installed plant cost per EDR, if anything, is rather high (it should be about $6.24) but is retained as basis for entire comparison to compensate for possible percentage errors.

To break above costs down per square foot:

Gross exterior wall: 123.4 sq. ft. requires a total of 18.6 EDR of heat per room:

26% is window or 32.1 sq. ft. with 77.4%
of total heat loss =
18.6 EDR x 77.4% = 14.4 EDR for window;
and 14.4 EDR @ $6.44/EDR = $92.74
of installed heat plant cost.
$92.74/32.1 sq. ft. = $2.89 per
sq. ft. of window area of installed
heating plant cost.
and 14.4 EDR @ $.68/EDR = $9.79 of
heat bill for one year.
$9.79/32.1 sq. ft. = $.31 per sq. ft.
of window area of heating bill
for one year.

74% is net (solid) wall or 91.3 sq. ft.
with 22.6% of total heat loss =
18.6 EDR x 22.6% = 4.2 EDR for wall
and 4.2 EDR @ $6.44/EDR = $27.09
of installed heat plant cost.
$27.09/91.3 sq. ft. = $.296 per
sq. ft. of net wall area of installed
heating plant cost.
and 4.2 EDR @ $.68/EDR = $2.93 of
heat bill for one year.
$2.93/91.3 sq. ft. = $.032 per
sq. ft. of net wall area of
heating bill for one year.

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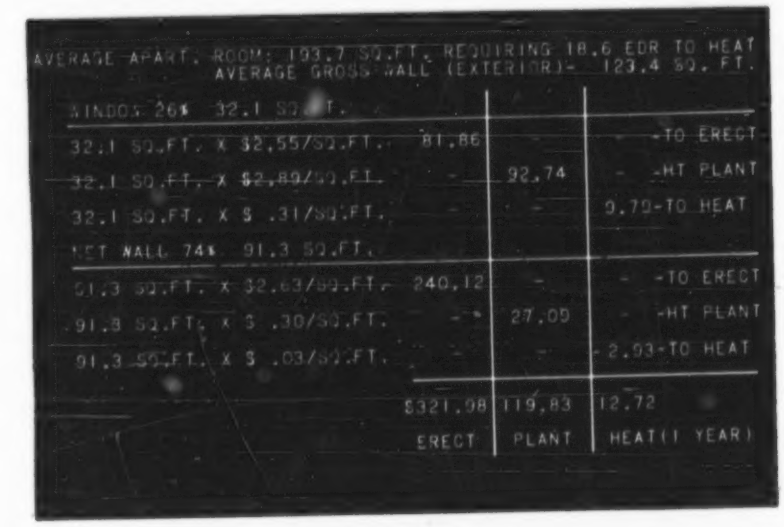
heat bill for one year.
/91.3 sq. ft. = \$.032 per
sq. ft. of net wall area of
heating bill for one year.

To summarize:
In a typical New York State housing project at present:

One square foot of:

A. Net (solid) wall—(U = .241)
Costs \$2.63 to install
(Calculated from unit costs)
Costs \$.296 of heat plant costs
Costs \$.032 to heat one year
(or \$.32 for 10 years and \$1.60 for 50 years)

B. Window (glass) wall—(U = 1.13)
Costs \$2.55 to install
(Cost furnished by Division of Housing)
Costs \$2.89 of heat plant costs
Costs \$ .31 to heat one year
(or \$3.10 for 10 years and \$15.50 for 50 years)



AVERAGE APART. ROOM: 193.7 SQ.FT. REQUIRING 18.6 EDR TO HEAT
AVERAGE GROSS WALL (EXTERIOR)- 123.4 SQ. FT.

WINDOW 26% 32.1 SQ.FT.			
32.1 SQ.FT. X \$2.55/SQ.FT.	81.86	-	- -TO ERECT
32.1 SQ.FT. X \$2.89/SQ.FT.	-	92.74	- -HT PLANT
32.1 SQ.FT. X \$ .31/SQ.FT.	-	-	9.79-TO HEAT
NET WALL 74% 91.3 SQ.FT.			
91.3 SQ.FT. X \$2.63/SQ.FT.	240.12	-	- -TO ERECT
91.3 SQ.FT. X \$ .30/SQ.FT.	-	27.09	- -HT PLANT
91.3 SQ.FT. X \$ .03/SQ.FT.	-	-	2.93-TO HEAT
	\$321.98	119.83	12.72
	ERECT	PLANT	HEAT(1 YEAR)

And combining for total wall:

C. Gross wall (32.1 glass plus 91.3 solid)
Costs \$2.61 to install (\$321.98 ÷ 123.4)
Costs \$ .97 of heat plant costs (\$119.83 ÷ 123.4)
Costs \$ .10 to heat for one year (\$12.72 ÷ 123.4)
or \$1.00 for 10 years and \$5.00 for 50 years

All calculations leading to cost figures for 1 sq. ft. as well as 123.4 sq. ft. of exterior wall based on contract drawings and interviews with project architects and engineers of "typical housing project." These typical cost figures above will now be used as a basis for the "comparative cost studies" that follow.

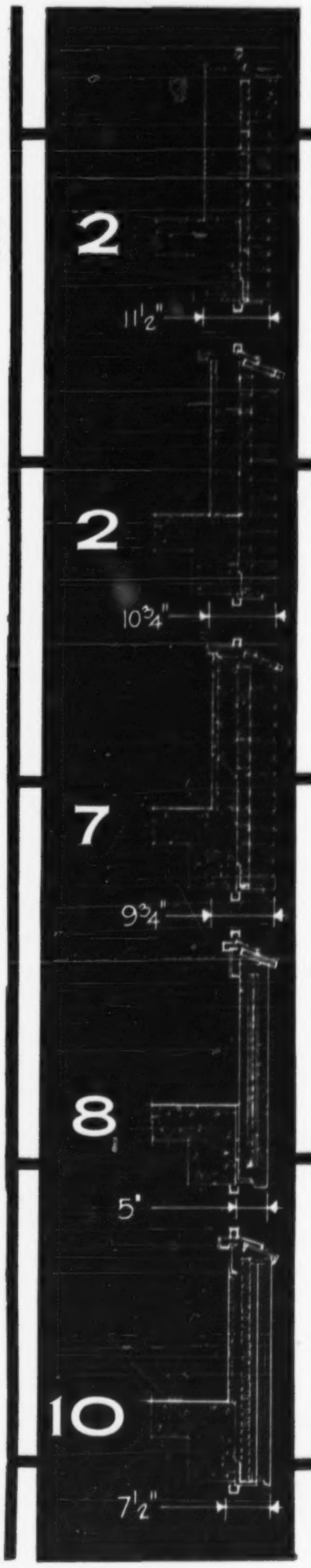
Comparative Cost Studies:

We have now established and explained our "measuring rod" for a typical exterior wall enclosing an "average apartment room."

Outside surface	—	.17	
4" common brick	1.41	.80	
6" cinder block	.66	1.40	
¾" furring and lath	.21	.91	
¾" plaster	.28	.23	
3 coats paint	.07	—	
Inside surface	—	.61	
	$2.63	**4.12**	**U=0.241 for solid wall**
	$2.55		**U=1.13 for glass wall**

With this data as background we will investigate 5 recommended walls. This comparative cost will cover first the solid wall only — then the window (glass) wall — finally the gross (solid and glass) wall.

As suggested at the end of Part 1 of this section — "A Typical Housing Project," it would be erroneous to assume a direct percentile relationship exists between "U" value (insulating capacity) of the exterior wall and the cost of the complete heating plant as initially installed. A reduction of the "U" value of 0.241 (present wall), costing $.30 per sq. ft. of net wall of the installed heating plant (i.e. burner, boiler, pipe runs & returns, radiation equipment, etc.) cannot directly reduce the cost of such a heating plant by an identical percentage. This would also apply to cutting fuel costs. For purposes of this comparison 75% of percent reduction of standard "U" value (in other words 75% of Column 6 of itemized chart) has been used to compensate for limited boiler size selection, "standard" commercially available piping, leakage in pipe runs, etc. This reduction, together with generally high "average" figures (i.e. - 9'-0" for floor-to-floor height of 8'-7" above 1st floor, $6.44 per EDR in lieu of calculated cost of $6.20 to $6.30 per EDR) used throughout this study should present a conservative cost comparison of the five exterior walls investigated.



Panel wall #3, U=0.123
Steel skin
See Wall No. 10

Panel wall #1, U=0.101
Precast concrete
See Wall No. 8

Cavity wall #4, U=0.061
Insulated alternate
See Wall No. 7

NYSDH wall, U=0.090
Insulated alternate
See Wall No. 2

NYSDH wall, U=0.129
Insulated
See Wall No. 2

ll
all

Panel wall #3, U=0.123
Steel skin
See Wall No. 10

Panel wall #1, U=0.101
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See Wall No. 8

Cavity wall #4, U=0.061
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See Wall No. 7

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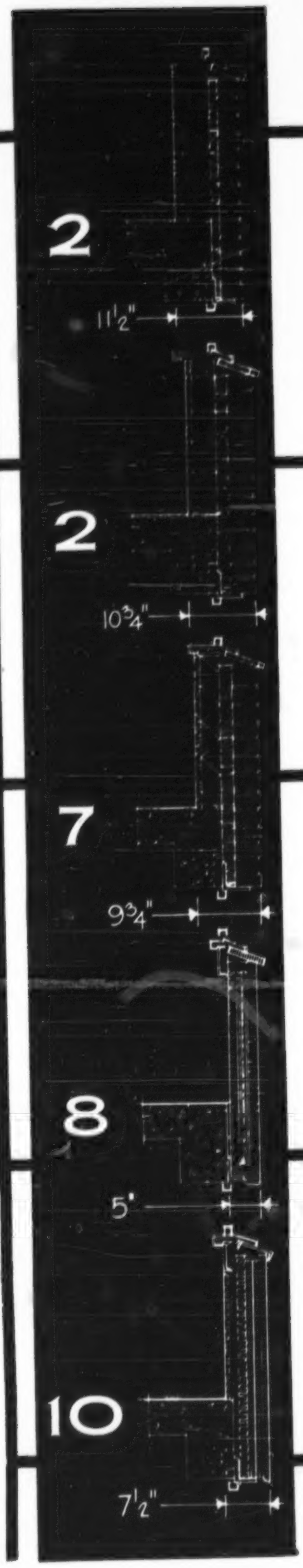
Insulated alternate
See Wall No. 2

NYSDH wall, U=0.129
Insulated
See Wall No. 2



1. **Present wall with 1" of Styrofoam directly behind brick.**
Cost: $2.92 = .29/sq. ft. over standard wall
U: 0.129 or 46.5% of 0.241 of standard wall
75% x 46.5 = 35.3% reduction (net)
Which is applied to heating plant
costs per sq. ft. and to fuel costs per sq. ft.
for 10 and 50 years.

2. **Present wall with 2" of Styrofoam directly behind brick; ½" plaster direct on block.**
Cost: $2.92 − .48 (lath & plaster) = $2.44
$2.44 + .17 (Styrofoam) & .22 (plaster) =
$2.83 = .20/sq. ft. over standard wall
U: 0.092 or 61.5% of 0.241 of standard wall
75% x 61.5 = 46.5% reduction (net)
which is applied to heating plant
costs per sq. ft. and to fuel costs per sq. ft.
for 10 and 50 years.

3. **Same as 2 above but with 3" cement-wood fiber block (Insulrock or equal) substituted for 4" cinder block. Exceptionally strong wall - easy to erect; very low U.**
Cost: $2.61 = .02/sq. ft. under standard wall
U: 0.061 or 74.7% of 0.241 of standard wall
75% x 74.7% = 55.3% reduction (net)
which is applied to heating plant
costs per sq. ft. and to fuel costs per sq. ft.
for 10 and 50 years.

4. **Panel Wall #1 - precast concrete: Because of low overall U-value this wall believed comfortable enough to omit plaster, thus alternate of Wall No. 8 used here.**
Cost: $3.16 − .48 (lath & plaster) = $2.67
$2.67 + .10 (finish) =
$2.77 = .14/sq. ft. over standard wall
U: 0.101 or 58.3% of 0.241 of standard wall
75% x 58.3 = 43.5% reduction (net)
which is applied to heating plant
costs per sq. ft and to fuel costs per sq. ft.
for 10 and 50 years.

5. **Panel Wall #3 - steel & gypsum board (vinyl-coated steel as developed by U. S. Steel - ribbed); channel, furring and plaster retained.**
Cost: $2.89 = .26/sq. ft. over standard wall
U: 0.112 or 53.6% of 0.241 of standard wall
75% x 53.6 = 40.5% reduction (net)
which is applied to heating plant
costs per sq. ft. and to fuel costs per sq. ft.
for 10 and 50 years.

S				2	2	
WALL TYPE S N.Y.S.D.H. WALL 'STANDARD' WALL		ITEMS COMPARED WITH STANDARD WALL		WALL TYPE 2 1" RIGID FOAM FURRING AND PLASTER	WALL TYPE 2 (ALT. DETAIL) 2" RIGID FOAM ½" DIRECT PLASTER	WA (ALT 4" 2" RI ½"
$2.63	(1)	COST OF NET (SOLID WALL IN PLACE PER SQUARE FOOT	(1)	$2.92	$2.83	
—		ADDITIONAL COST PER SQ. FT. OVER STANDARD WALL		$0.29	$0.20	
12¾"		TOTAL THICKNESS OF WALL; SEE HORIZ. AND VERT. SECTIONS		11½"	10¾"	
—		PERCENTAGE REDUCTION OF WALL THICKNESS OVER STANDARD		9.9%	14.8%	2
0.241		CALCULATED U-VALUE OF WALL; SEE HORIZ. AND VERT. SECTIONS		0.129	0.092	0
—		PERCENTAGE REDUCTION OF U-VALUE OVER STANDARD		46.5%	61.5%	7
—	(2)	TAKING 75% OF PERCENTAGE REDUCTION OF THIS U-VALUE	(2)	35.3%	46.5%	5
$0.296	(3)	HEATING PLANT COSTS PER SQ. FT. OF WALL REDUCED BY (2)	(3)	$.296-.105 0.19	$.296-.141 0.16	$.2
$2.93	(4)	ADJUSTED GROSS WALL COST IN PLACE: ITEM (1) + ITEM (3)	(4)	$3.11	$2.99	
—		IMMEDIATE SAVING PER SQ. FT. OF WALL: ITEM (1) — ITEM (4)		— —	— —	$2.
$0.30		IMMEDIATE ADDITIONAL COST OF WALL: ITEM (4) — ITEM (1)		$3.11-2.93 0.18	$2.99-2.93 0.06	
$0.32	(5)	10-YEAR HEATING BILL COSTS PER SQ. FT. REDUCED BY (2)	(5)	$.32-.112 0.21	$.32-.150 0.17	$.
$3.25	(6)	ADJUSTED 10-YR. GROSS WALL COST OF WALL: ITEM (4) + ITEM (5)	(6)	$3.32	$3.16	
—		10-YEAR SAVING OF HEATING OF WALL: COMPARING ITEM (6)		—	$0.09	
$1.60	(7)	50-YEAR HEATING BILL COSTS PER SQ. FT. REDUCED BY (2)	(7)	$1.60-0.56 1.04	$1.60-0.75 0.85	$1.
$4.53	(8)	ADJUSTED 50-YR. GROSS WALL COST OF WALL: ITEM (4) + ITEM (7)	(8)	$4.36	$3.84	
—		50-YEAR SAVING OF HEATING OF WALL: COMPARING ITEM (8)		$0.17	$0.69	

COMPARATIVE COST RESULTS: READ ACROSS FOR COMPARISON OF EACH ITEM AND READ DOWN EAC

2	2	7	8	10
WALL TYPE 2 1" RIGID FOAM FURRING AND PLASTER	WALL TYPE 2 (ALT. DETAIL) 2" RIGID FOAM ½" DIRECT PLASTER	WALL TYPE 7 (ALTER. NO. 1) 4" BRICK + 2" RIGID FOAM ½" PLASTER	WALL TYPE 8 PRECAST CONCRETE	WALL TYPE 10 STAINLESS STEEL GYPSUM BOARDS
$2.92	$2.83	$2.61	$2.77	$2.89
$0.29	$0.20	—	$0.14	$0.26
11½"	10¾"	9¾"	5"	7½"
9.9%	14.8%	23.5%	60.8%	41.2%
0.129	0.092	0.061	0.101	0.112
46.5%	61.5%	74.7%	58.3%	53.6%
35.3%	46.5%	55.3%	43.5%	40.5%
$.296-.105 0.19	$.296-.141 0.16	$.296-.165 0.13	$.296-.132 0.16	$.296-.123 0.17
$3.11	$2.99	$2.74	$2.93	$3.06
— —	— —	$2.93-2.74 0.19	— NET	— —
$3.11-2.93 0.18	$2.99-2.93 0.06	— —	— NET	$3.06-2.93 0.13
$.32-.112 0.21	$.32-.150 0.17	$.32-.176 0.14	$.32-.141 0.18	$.32-.131 0.19
$3.32	$3.16	$2.88	$3.11	$3.25
—	$0.09	$0.37	$0.14	NET
$1.60-0.56 1.04	$1.60-0.75 0.85	$1.60-0.88 0.72	$1.60-0.70 0.90	$1.60-0.66 0.94
$4.36	$3.84	$3.46	$4.01	$4.19
$0.17	$0.69	$1.07	$0.52	$0.34

PARISON OF EACH ITEM AND READ DOWN EACH COLUMN FOR COMPLETE WALL DATA

Comparative Cost Studies:

The preceding chart has analyzed the comparative costs of five wall systems against a "measuring rod" — the public housing exterior wall now in use. All the values given with corresponding costs in that chart are based on the "net" (solid) exterior wall: that is, the gross exterior wall minus the window area. This, as our analysis of an "average apartment room" showed, accounted for 74% of the gross exterior wall (a large amount in square feet) but only 22.6% of total heat loss (a small percentage of installed heating plant and future fuel costs) in a room.

In the "Comparative Cost Study" we will investigate the insulation vs. cost data of the remaining 26% of the gross exterior wall which accounts (through window glass and window frame infiltration) for 77.4% of total heat loss (a large percentage of installed heating plant and future fuel costs) in a room. Again we return to our "measuring rod" (the present exterior wall) for the cost comparison. However, in this case we shall use first the values arrived at to erect, provide heat for, and heat the window (glass) wall and then the combined values to erect, provide heat for, and heat the gross wall (window and net (solid) wall). In effect, a cost comparison of a completely insulated exterior wall will be made based on the cost (initial and future) of the present, completely uninsulated exterior wall with the following premises:

Using cost data for present exterior wall as per calculations in the summary to "An Average Apartment Room."

Using for "net" (solid) part of wall Alternate 1 of Wall No. 7 as per cost comparison on preceding chart. This wall selected (and strongly recommended) since it is a sound masonry wall that could be immediately substituted for the present masonry wall with no change in Division of Housing standards or New York City Code, nor require any radical change in normal New York City trade union practices.

Using for this wall (No. 7) a design temperature of 5° to 70°=65° F in lieu of present 0° to 70°=70° F. This is in line with suggestions made by engineering firms during field interviews on subject. A typical calculation sheet of heat loss per room (see photostat — "A Typical Housing Project"), reveals more than adequate (10% factor) compensation for this sensible change of design standards.

Using standard (commercial aluminum double-hung — Ceco or equal) windows with DSB glass for present wall:

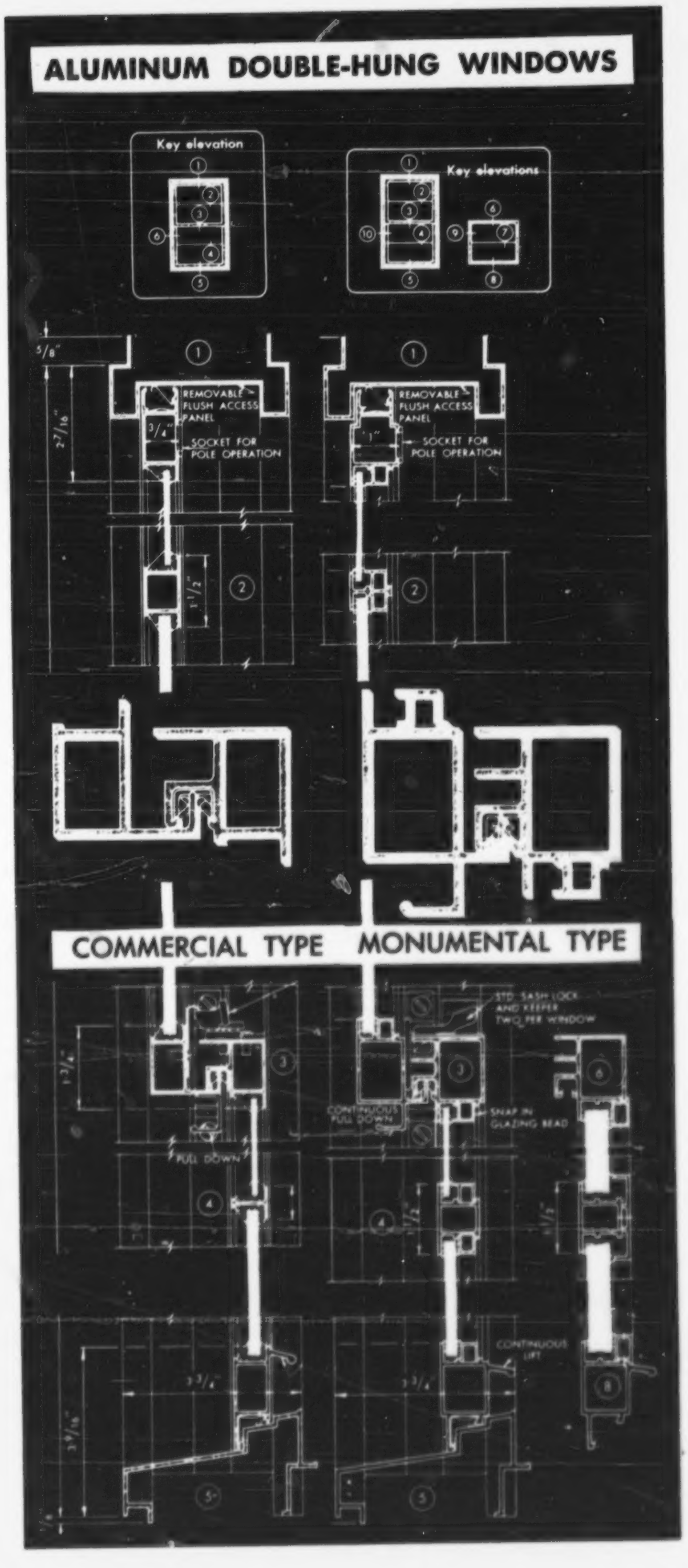
Price: N.Y.C., installed, 3'-0" x 5'-1½"
frame—$30.00; glazing—$8.25
Total: $38.25 ÷ 15 sq. ft. = $2.55 PSF
Factor: U x °F = 1.13 x 70° = 79.10

Using monumental (aluminum double-hung — Ceco or equal) windows with ½" double-glazing for recommended Wall No. 7:

Price: N.Y.C., installed, 3'-0" x 5'-1½"
frame—$75.00; glazing—$44.20
Total: $119.20 ÷ 15 sq. ft. = $7.94 PSF
Factor: U x °F = .65 x 65° = 45.50, or
Reduction of 42.5% of above factor of 79.10

Above prices are current volume installations in New York City (Summer-'58); double-glazed units installed only above third floor up to minimize breakage; added benefit of double-glazed unit is reduced infiltration losses (about 5%-8% - see comparative sections) of improved frame, resulting in reduced infiltration factor in calculation of heat losses per room; check of material supply houses shows at least six producers of aluminum double-hung windows which can accommodate ½" double-glazing.

Using for this wall (No. 7) a design temperature of 5° to 70° = 65° F in lieu of present 0° to 70° = 70° F. This is in line with suggestions made by engineering firms during field interviews on subject. A typical calculation sheet of heat loss per room (see photostat — "A Typical Housing Project"), reveals more than adequate (10% factor) compensation for this sensible change of design standards.


ALUMINUM DOUBLE-HUNG WINDOWS
Key elevation
Key elevations
REMOVABLE FLUSH ACCESS PANEL
SOCKET FOR POLE OPERATION
COMMERCIAL TYPE
MONUMENTAL TYPE
STD. SASH LOCK AND KEEPER TWO PER WINDOW
CONTINUOUS PULL DOWN
SNAP IN GLAZING BEAD
PULL DOWN
CONTINUOUS LIFT

Using standard (commercial aluminum double-hung — Ceco or equal) windows with DSB glass for present wall:

Price: N.Y.C., installed, 3'-0" x 5'-1½"
frame—$30.00; glazing—$8.25
Total: $38.25 ÷ 15 sq. ft. = $2.55 PSF
Factor: U x °F = 1.13 x 70° = 79.10

Using monumental (aluminum double-hung — Ceco or equal) windows with ½" double-glazing for recommended Wall No. 7:

Price: N.Y.C., installed, 3'-0" x 5'-1½"
frame—$75.00; glazing—$44.20
Total: $119.20 ÷ 15 sq. ft. = $7.94 PSF
Factor: U x °F = .65 x 65° = 45.50, or
Reduction of 42.5% of above factor of 79.10

Above prices are current volume installations in New York City (Summer-'58); double-glazed units installed only above third floor up to minimize breakage; added benefit of double-glazed unit is reduced infiltration losses (about 5%-8% - see comparative sections) of improved frame, resulting in reduced infiltration factor in calculation of heat losses per room; check of material supply houses shows at least six producers of aluminum double-hung windows which can accommodate ½" double-glazing.

We have now outlined the premises under which the final cost comparison of this portion of the report is to be made. With these basic facts and figures — discussed with architectural and engineering offices who designed the housing project under construction in the Bronx — the present completely uninsulated exterior wall ("standard" wall shown on first page of this Chapter) can be compared cost-wise with the "recommended wall" (wall No. 7 modified as per alternate detail No. 1) two ways: using Styrofoam and single-glass and finally using Styrofoam and double-glass. First, a clear tabulation of these 3 wall types:

A. The "standard" wall — single-glazed; uninsulated

1. Net (solid) wall costs are as follows:
Net wall accounts for 22.6% of heat loss from average room.
Costs $2.63 PSF to furnish and install (N.Y.C. '58)
$ .296 PSF of heating plant costs
$ .32 PSF of heating bill for 10 years
$1.60 PSF of heating bill for 50 years

2. Window (glass) wall costs are as follows:
Glass accounts for 77.4% loss of heat from average room.
Infiltration loss is 31.5%; glass loss is 45.9%
Costs $ 2.55 PSF to furnish and install (N.Y.C. '58)
$ 2.89 PSF of heating plant costs
$ 3.10 PSF of heating bill for 10 years
$15.50 PSF of heating bill for 50 years

All of the above facts and figures from "Average Apartment Room" portion of this Chapter.

B. Recommended wall (Wall No. 7) — single-glazed; insulated

1. Net (solid) wall costs are as follows:
Net wall accounts for 22.6% of heat loss from average room.
Costs $2.61 PSF to furnish and install (N.Y.C. '58)
$ .13 PSF of heating plant costs
$ .14 PSF of heating bill for 10 years
$ .72 PSF of heating bill for 50 years

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2. Window (gla
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$ 2.89
$ 3.10
$15.50

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C. Recommended

1. Net (solid) wa
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$ .14 P
$ .72 P

2. Window (glas
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This is now a
Costs $ 7.94
$ 2.89
$ 2.43
$ 3.10
$ 2.60
$15.50
$13.00

All of th
"Compa

2. Window (glass) wall costs are as follows:
Glass accounts for 77.4% of heat loss from average room
From figures (A2) above:
Costs $ 2.55 PSF to furnish and install (N.Y.C. '58)
$ 2.89 PSF of heating plant costs
$ 3.10 PSF of heating bill for 10 years
$15.50 PSF of heating bill for 50 years

All of the above figures from "Average Apartment Room" and "Comparative Cost Studies" (chart) of this Chapter.

C. Recommended wall (Wall No. 7) — double-glazed; insulated

1. Net (solid) wall costs are as follows:
Net wall accounts for 22.6%of heat loss from average room.
Costs $2.61 PSF to furnish and install (N.Y.C. '58)
$ .13 PSF of heating plant costs
$ .14 PSF of heating bill for 10 years
$ .72 PSF of heating bill for 50 years

2. Window (glass) wall costs are as follows:
Glass accounts for 77.4% of heat loss from average room.
Infiltration loss is 31.5% and glass loss is 45.9%
Reduce infiltration loss by 75% of 5% or 30.3% (better frames).
Reduce glass loss by 75% of 45.9% or 31.3% (double-glazing).

As suggested, this is 75% of total direct reduction.
Thus total window loss (77.4%) reduced to 61.6%.
This is now a direct saving of 15.8% of heat lost.
Costs $ 7.94 PSF to furnish and install (N.Y.C. '58)
$ 2.89 PSF of heating plant costs reduces to:
$ 2.43 PSF (2.89 minus 15.8% x 2.89).
$ 3.10 PSF of heating bill for 10 years reduces to:
$ 2.60 PSF (3.10 minus 15.8% x 3.10).
$15.50 PSF of heating bill for 50 years reduces to:
$13.00 PSF (15.50 minus 15.8% x 15.50).

All of the above facts and figures from first part of "Comparative Cost Studies" portion of this Chapter.

D. Combining information above for gross wall:

(total wall area = 123.4 sq. ft.)
(net (solid) wall = 91.3 sq. ft.)
(window wall = 32.1 sq. ft.)

It is now possible to take unit costs of wall in place, heating plant costs and heating costs (as itemized in A ,B and C above) and multiply out these unit costs by total square feet of glass and net wall of our typical housing example and divide by 123.4 sq. ft. to arrive at combined gross costs per square foot of total wall (in place with equipment required to compensate for heat loss of each wall) for 3 possibilities:

1. present "standard" wall — uninsulated
2. recommended wall — wall insulated
3. recommended wall — wall and glass insulated

1. "Standard" wall (123.4 sq. ft.) — uninsulated:

Costs $2.61 PSF to furnish and install (N.Y.C. '58)
$ .97 PSF of heating plant costs
Thus, adjusted gross wall cost in place:
$3.58 PSF (wall and heat plant)
and: $1.00 PSF of heating bill for 10 years.
$5.00 PSF of heating bill for 50 years.

2. Recommended wall (123.4 sq. ft.) wall with Styrofoam

Costs $2.59 PSF to furnish and install (N.Y.C. '58)
$ .85 PSF of heating plant costs.
Thus, adjusted gross wall cost in place:
$3.44 PSF (wall and heat plant)
and: $ .91 PSF of heating bill for 10 years.
$4.55 PSF of heating bill for 50 years.

3. Recommended wall (123.4 sq. ft.) Styrofoam and double-glass

Costs $3.98 PSF to furnish and install (N.Y.C. '58)
$ .73 PSF of heating plant costs
Thus, adjusted gross wall cost in place:
$4.71 PSF (wall and heat plant)
and: $ .78 PSF of heat bill for 10 years.
$3.90 PSF of heat bill for 50 years.

All of the above calculations completed as per first paragraph above (D) and data in paragraphs (A), (B) and (C).

This second part of the comparative cost study indicates for the total exterior wall:

A. The recommended wall (solid wall insulated only) costs $.14 less PSF to install in public housing work (immediate saving) and saves $.01 PSF each year of the heating bill (future saving). It is worth mentioning at this point that the typical housing project used throughout this study will have, when completed, approximately 84,650 square feet of total exterior wall enclosing 39 wings (excluding the additional walls of the central cores which consisted of a curtain-wall type of enclosure omitted in this study — i.e. - "wings" assumed closed-off at negligibly small core connection).

B. The recommended wall (solid and glass wall insulated) costs $1.13 more to install in public housing work (immediate additional cost) and saves $.02 to $.03 PSF each year of the heating bill.

Clearly, complete insulation (at least as theoretically established from confirmed field data in this report) is a long-range cost saving program. However, the initial extra cost is low enough and the savings in installation and operating costs large enough to suggest that the Division of Housing investigate now or in the near future the possibilities of a fully insulated wall. Several suggestions to reduce high initial cost of double-glazing are offered to make this possible:

> Try a good wood window unit — balance low cost and low heat loss with high maintenance of unit.
>
> Experiment with commercial double-hung aluminum window (70% less cost) adapted to accept double-glazing.
>
> Try out a good aluminum sliding window unit — presently available - easily takes double-glazing.
>
> Encourage more window companies to experiment with and produce low cost aluminum windows for double-glazing.
>
> Experiment with detailing a complete double-glazed window unit as integral part of a prefabricated wall — as part of Wall No. 8 or 10.

On the other hand, insulation of the "net" exterior wall — omitting double-glazing of windows — is definitely an immediate cost saving program — as all the data in this report indicate. This applies for the present exterior wall as well as the proposed panel walls. Actual field evaluation of any of the insulated walls would help establish just how liberal the reduced percentage of heat loss reduction is, set direct relationships between insulated wall costs and costs of installed heat plant and future fuel costs, and finally, clearly establish the gross cost-in-place of an insulated exterior wall. This can not be recommended too strongly.

It is a measure of the seriousness of this recommendation and of the intent to search out "ways of reducing the cost of public housing" on the part of the New York State Division of Housing that additional funds have been made available by the Division of Housing to carry out this recommendation. In the early part of 1959 an Experimental Testing Shed was erected on the campus of Pratt Institute with funds made available to the School of Architecture by the Division of Housing. A slightly modified version of the "recommended" wall of this report as approved by the Division of Housing was erected next to a panel of the present "standard" wall. Every effort has been made to duplicate actual field conditions for these two wall panels. They are each mounted on a concrete frame and each has one double-hung window unit in the middle of the panel in strict accordance with the final drawings of the typical housing project mentioned in this report. The rest of the shed encloses these 2 exterior wall panels separately with proper insulation and heating elements to simulate actual "average apartment heating." Thermocouples and wall probes have been built into each panel to register temperatures, determine actual "U" values, check dew points, etc. Detailing, construction and supervision of the Testing Shed is under the direction of a research staff of the School of Architecture at Pratt Institute. Testing instruments have been supplied by and readings are under the supervision of a research staff of Brooklyn Polytechnic Institute. In addition to funds, the New York State Division of Housing furnished some building materials; Insulrock panels for the recommended wall were furnished by the Insulrock Division of the Flintkote Corp., East Rutherford, New Jersey; Styrofoam panels for the recommended wall were furnished by the Dow Chemical Co., New York City. It is the aim of this research project to test these two wall panels (and other panels if additional funds are made available) for one complete winter heating cycle.

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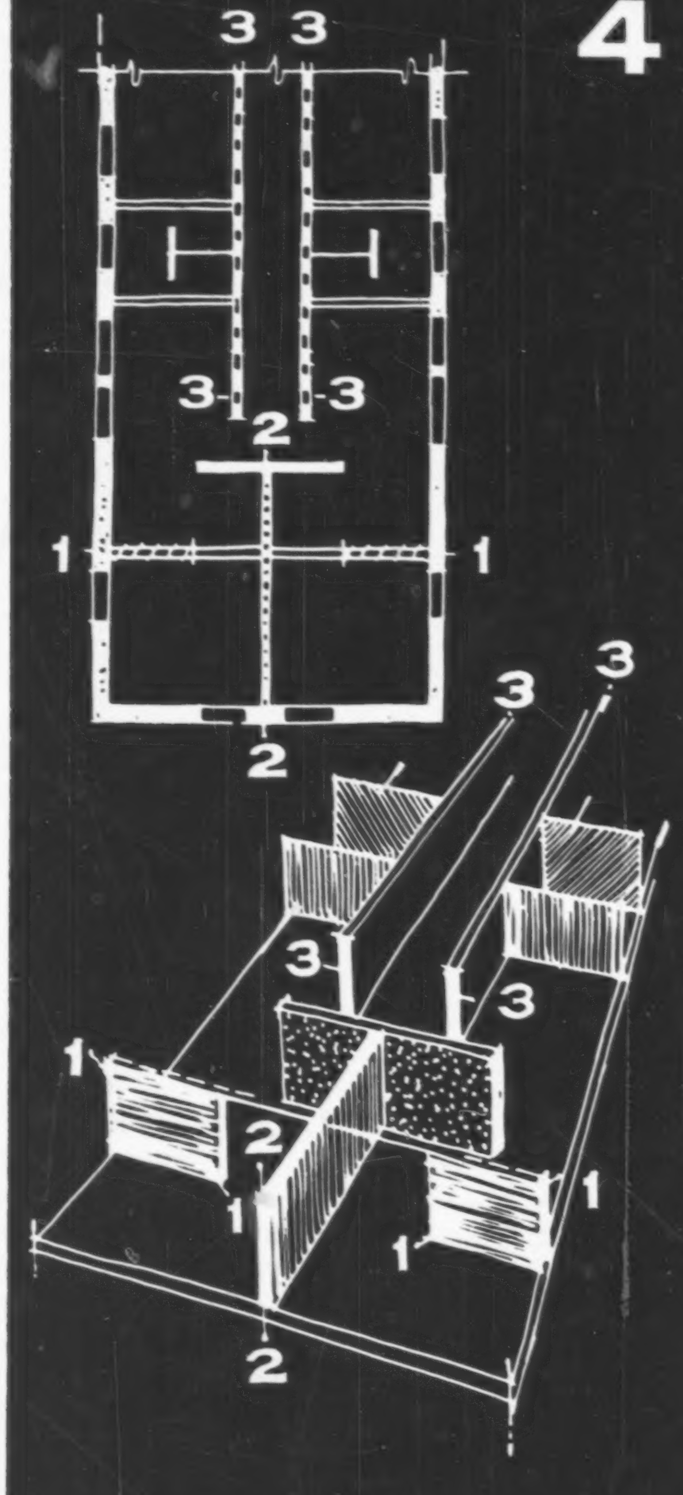
CHAPTER FOUR — INTERIOR ELEMENTS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In this Chapter interior partitions of all types, as well as interior finishes, are closely scrutinized for possible cost savings. The economies that might be achieved by reducing the ceiling height are also discussed.

In this field, perhaps more than in any other, the need for soundly based and clearly stated standards of quality, is paramount. The stated policy of the Division of Housing calls for "decent, safe, and sanitary" housing with no luxuries. No one can quarrel with this policy, but precisely how does it apply to such a subject, say, as the grinding of the form marks from the concrete ceilings? How smooth must the ceiling be to qualify as "decent, safe, and sanitary?" Or perhaps a smooth ceiling should be considered an aesthetic delight and hence a luxury? Such considerations constantly handicapped the cost studies reported in this Chapter.

One consideration that distinguishes New York City public housing from almost all other building types, is the extraordinary punishment that it must be prepared to take from vandals. This fact, plus the long (fifty-year) life assumed for the buildings, has led to the use of such durable but expensive materials as glazed structural facing tile for the long, narrow, dimly lit public corridors. Perhaps a less expensive wall material, with improved lighting, would result in less vandalism and a lower overall cost.

The thickness of partitions can be a significant item in the cost analysis, and it should not be ignored. If room sizes are held constant, an increase in the thickness of the partitions requires an increase in the gross area of the building. Since the building structure (columns, beams, and floor slabs) costs about $3.00 per square foot of floor area, each inch of thickness of a partition one foot long costs about 25c, or about 3c per square foot for a partition eight feet high. This cost, 3c per square foot per inch of thickness, should be added to the construction cost in order to make an accurate cost comparison between various partitions.

Four types of partitions are considered in the following pages: partitions within an apartment, between adjacent apartments, between an apartment and the public corridor, and between the stair hall and the public corridor. A number of alternate constructions are given for each of the four types. The alternate constructions are analyzed as to cost, maintenance, sound reduction, and fire resistance, and compared with the standard construction now used.

The interior finish surfaces studied in this Chapter include floors (within apartments, in public corridors, elevator lobbies, and bathrooms), ceilings, and bathroom walls around the tub. Other wall finishes are covered in the section on partitions.

That a substantial cost saving could be achieved by lowering the ceiling six inches, is hardly debatable. The question is whether such a change is advisable. This is not an immediate possibilty anyway, because the laws of both the cty and the state would have to be amended to permit ceilings less than eight feet high. The subject has been studied at considerable length and some of the results are presented in the last section of this Chapter.

THE INTERIOR ELEMENTS

1 Partitions

The first group of interior elements to be examined consists of interior partitions. This includes a study of all wall areas in public housing work other than the exterior wall. Partitions as considered in this section may be constructed of commonly used materials or may be constructed of relatively new materials. All materials suggested meet all the requirements of sound construction and good practice although not necessarily all of the present requirements of the New York State Division of Housing.

In order to develop a comparative method of cost analysis, the partitions under consideration are divided into the following subdivisions:

a Partitions within apartments.

b Partitions between public halls and apartments.

c Partitions between elevators, stairs and halls.

d Partitions between apartments.

This area of construction has been investigated, to a great extent, because there has developed in public housing work a stereotyped selection of partition materials, even though suitable substitutes are now on the market. It is not the purpose of this report to recommend experimental materials, but to suggest those that have been successfully tested in many areas of private, semi-public and public construction. The Division of Housing does select excellent materials for its construction, but in almost all instances the materials are more costly than the possible substitutes.

A testing program (more extensive than the present limited program conducted under the direction of the Division of Housing) is suggested as a worth while way of investigating and specifying new materials which may prove to be far superior to present materials accepted and specified without question in public housing work.

A detail section is shown of all partitions with component materials and sizes noted. Unit cost and available technical data is also indicated. Each construction type is further described and examples of possible application shown.

Although the cost saving possibilities of prefabricating some or all of the interior partition elements within a typical floor have not been covered within the body of this portion of the report, it is not intended that this cost-reducing area be entirely overlooked. Because of the somewhat intangible cost data presently available concerning prefabricated partition units (erected in place), it was decided to suggest in this introduction that the Division of Housing develop some type of thorough research program (in addition to the enlarged testing program recommended above) to investigate under actual field conditions (i.e. - erection in occupied apartments) a variety of currently available prefabricated partition systems which could be purchased, erected, tested and priced. So many workable prefabricated partition systems suggest the reduction of installation time and cost that they merit close investigation by any public agency interested in the economical, efficient enclosure of space without sacrificing any livable quality within that enclosed space.

The only Building Code revisions that would be required to carry out any suggestions made here would concern the use of wood studs within apartments. The danger due to fire is virtually eliminated in this type of construction due to the surfacing of the studs with plaster or gypsum board. Each apartment would be separated from the next by fire-rated walls, ceilings, and floors. Construction of wood stud partitions within fireproof apartments is acceptable in other cities such as Washington, D.C.

The cost information used in this Chapter was obtained with the cooperation of H. Nash Babcock, Consulting Engineer, Old Greenwich, Conn. These are average unit costs for low-cost housing erected on a large scale in New York City (Summer 1957) and will vary somewhat depending on building locality, complexity of partition layout and condition of the market at bid time.

The floor plan shown below represents a typical wing of a project now under construction in New York City. This floor plan, and its variations, are duplicated approximately 400 times in 14 buildings in the project. All partition cost reductions will be compared to this plan to show a possible total project saving for each item considered. All partitions have a Transmission Loss (T.L.) rating stated in decibels.

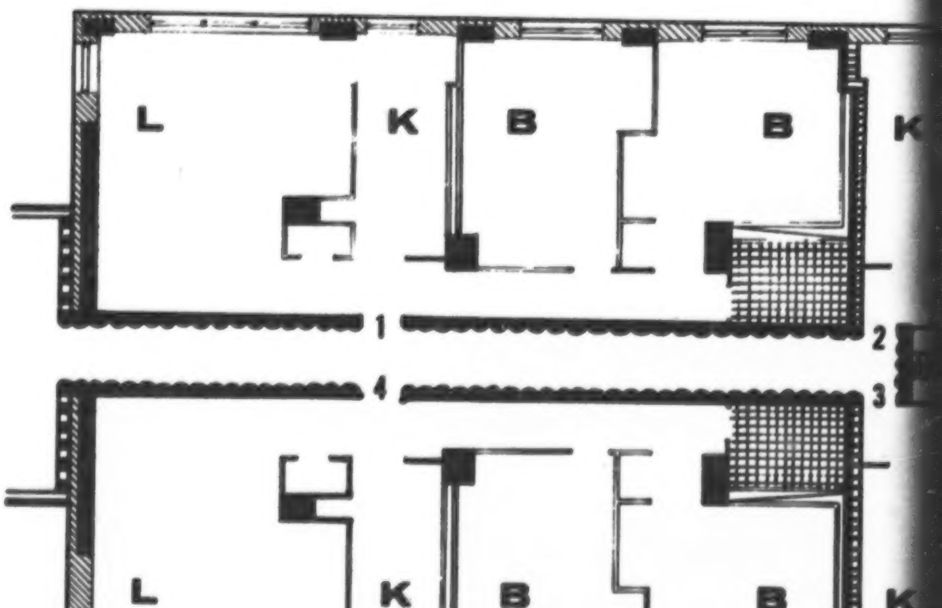
PARTITIONS WITHIN APARTMENTS

PARTITIONS BETWEEN PUBLIC HALLS AND APART

PARTITIONS BETWEEN ELEVATORS, STAIRS AND H

PARTITIONS BETWEEN APARTMENTS

TYPICAL FLOOR PLAN — PROJECT WING
PARTITION SYMBOLS



plan shown below represents a typical wing
ect now under construction in New York City.
r plan, and its variations, are duplicated
nately 400 times in 14 buildings in the pro-
partition cost reductions will be compared to
to show a possible total project saving for
m considered. All partitions have a Trans-
Loss (T.L.) rating stated in decibels.

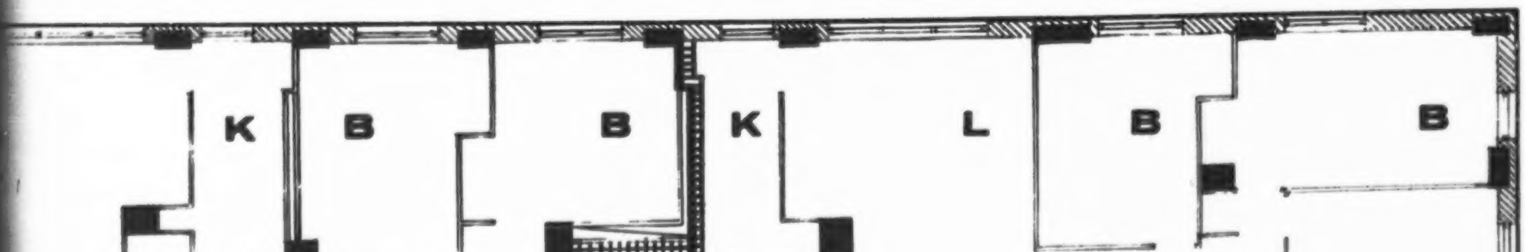
IONS WITHIN APARTMENTS : ═

IONS BETWEEN PUBLIC HALLS AND APARTMENTS : ▬

IONS BETWEEN ELEVATORS, STAIRS AND HALLS : ▪▫▪▫

IONS BETWEEN APARTMENTS : ▥

L FLOOR PLAN — PROJECT WING
ION SYMBOLS

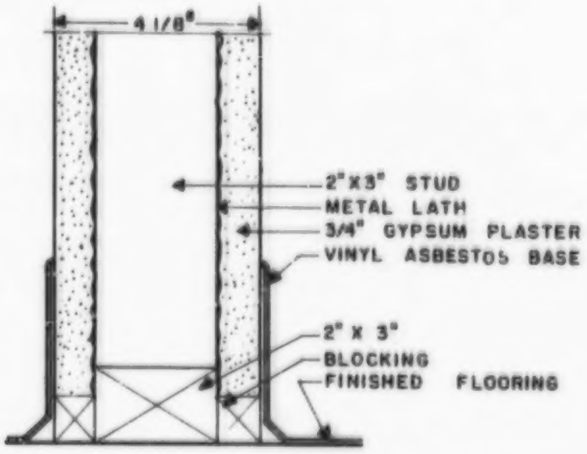


Partitions: Within Apartments

¾" lath and plaster on wood studs

Typical plaster partition as used in non-fireproof construction. At present not permitted by Building Code. It is a durable partition — originally thought to be cheaper than 2" solid plaster but cost data proves otherwise.

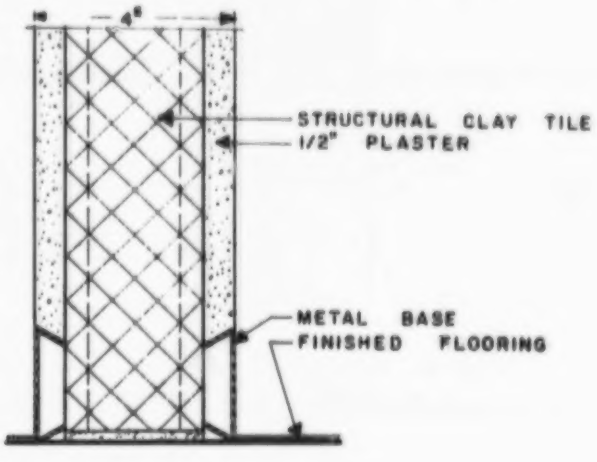
Weight: 19 lbs./sq. ft.
Fire rating: 1 hour
T. L.: 38 decibels
Cost: $1.26/sq. ft.


4 1/8"
2"X3" STUD
METAL LATH
3/4" GYPSUM PLASTER
VINYL ASBESTOS BASE
2" X 3"
BLOCKING
FINISHED FLOORING

½" plaster on 3" structural clay tile

Typical partition used in fireproof construction. Durable — withstands moisture. More expensive than gypsum block.

Weight: 28 lbs./sq. ft.
Fire rating: Over 1 hour
T. L.: 40 decibels
Cost: $.92/sq. ft.

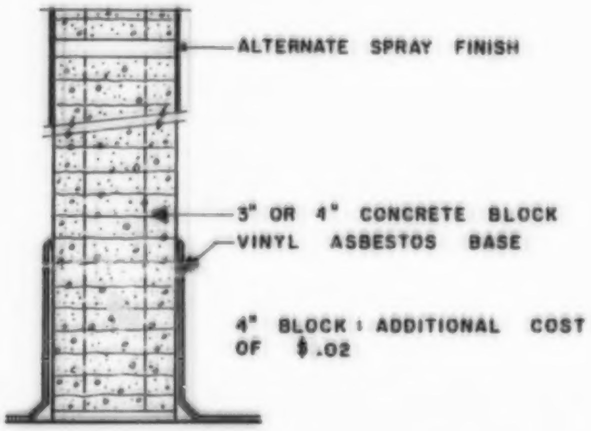

4"
STRUCTURAL CLAY TILE
1/2" PLASTER
METAL BASE
FINISHED FLOORING

Exposed 3" concrete block (alternate with sprayed cement or plastic finish)

Used extensively as partitions for schools, residences and private apartments. Disadvantage of having rough surface which tends to accumulate dirt. Spray finish would eliminate this. (Example: Levitt Apartments - N.Y.C.)

Weight: 20 lbs./sq. ft.
Fire rating: 1 hour (solid Waylite)
Cost: $.50/sq. ft.

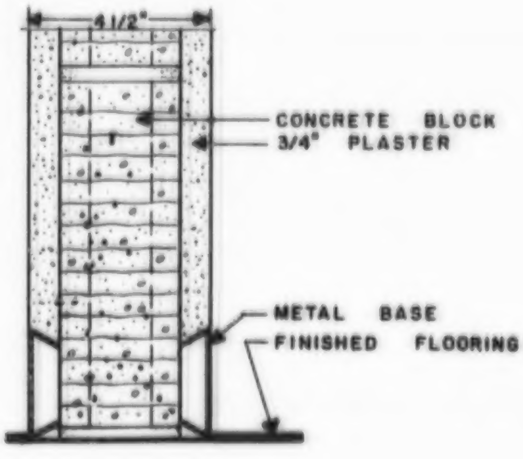
Additional cost for spray finish would be between $.50 and $.60/sq. ft. per side.


ALTERNATE SPRAY FINISH
3" OR 4" CONCRETE BLOCK
VINYL ASBESTOS BASE
4" BLOCK : ADDITIONAL COST OF $.02

¾" plaster on 3" concrete block

Durable and easily maintained surface. More expensive than gypsum and structural tile.

Weight: 30 lbs./sq. ft.
Fire rating: 1 hour
T. L.: 45 decibels
Cost: $1.12/sq. ft.


4 1/2"
CONCRETE BLOCK
3/4" PLASTER
METAL BASE
FINISHED FLOORING

Exposed 3" concrete block (alternate with sprayed cement or plastic finish)

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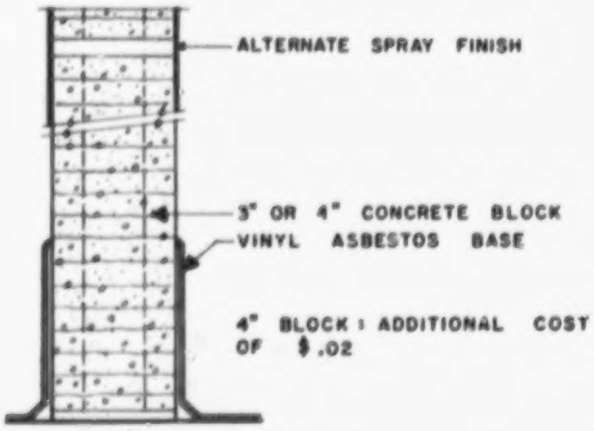
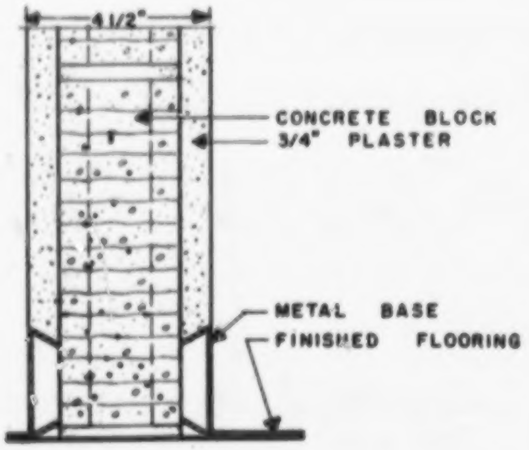

ALTERNATE SPRAY FINISH
3" OR 4" CONCRETE BLOCK
VINYL ASBESTOS BASE
4" BLOCK : ADDITIONAL COST OF $.02

¾" plaster on 3" concrete block

Durable and easily maintained surface. More expensive than gypsum and structural tile.

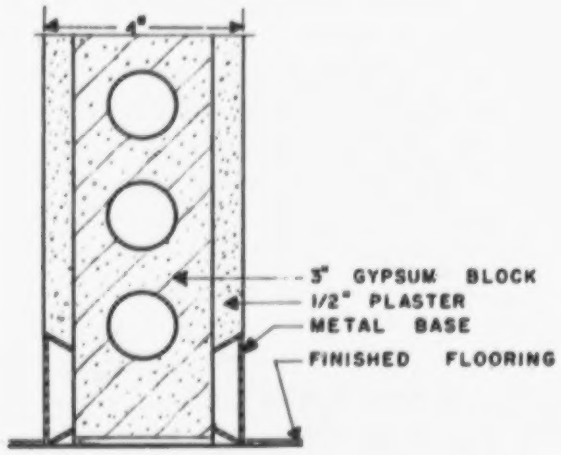
Weight: 30 lbs./sq. ft.
Fire rating: 1 hour
T. L.: 45 decibels
Cost: $1.12/sq. ft.


4 1/2"
CONCRETE BLOCK
3/4" PLASTER
METAL BASE
FINISHED FLOORING

½" plaster on 3" gypsum block

Typical partition used in fireproof construction. Lightweight, durable, and because of large size, 3 x 12 x 30, easily erected.

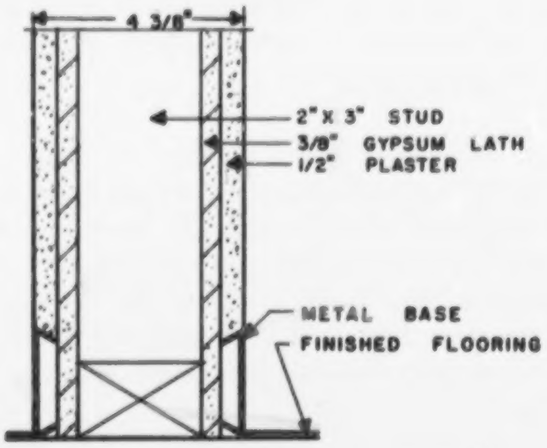
Weight: 21.8 lbs./sq. ft.
Fire rating: 3 hour
T. L.: 37.8 decibels
Cost: $.88/sq. ft.


4"
3" GYPSUM BLOCK
1/2" PLASTER
METAL BASE
FINISHED FLOORING

½" plaster on ⅜" gypsum lath on wood studs

Typical plaster partitions used in non-fireproof construction. At present not permitted by Building Code in fireproof construction. A durable easily maintained partition.

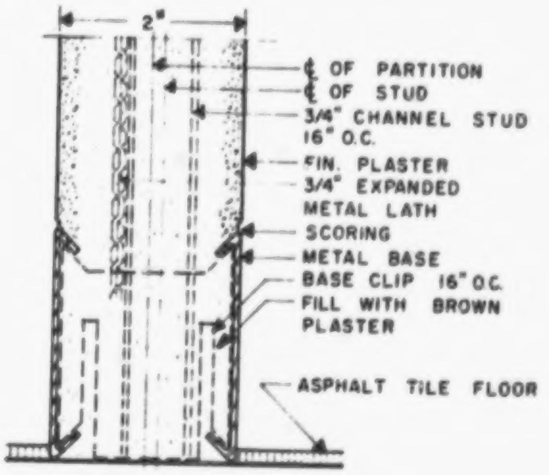
Weight: 9-16 lbs./sq. ft.
Fire rating: 45 minutes to 1 hour
T. L.: 35 decibels
Cost: $.88/sq. ft.


4 3/8"
2"X 3" STUD
3/8" GYPSUM LATH
1/2" PLASTER
METAL BASE
FINISHED FLOORING

2" solid plaster

Typical plaster partition used in New York City projects. Advantages are that it is a thin and lightweight partition.

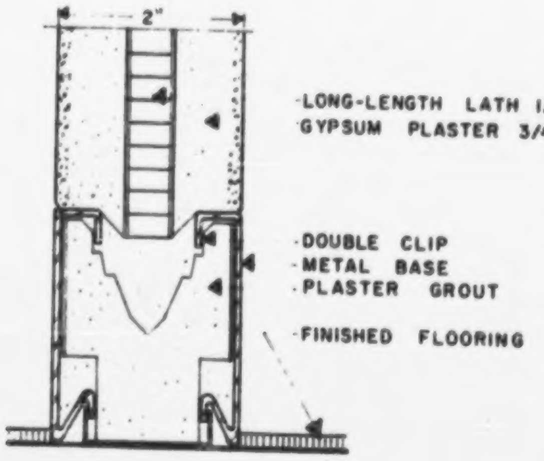
Weight:	18 lbs./sq. ft. gypsum plaster
Fire rating:	1 hour
T. L.:	35 decibels
Cost:	$.92/sq. ft.


2"
℄ OF PARTITION
℄ OF STUD
3/4" CHANNEL STUD 16" O.C.
FIN. PLASTER
3/4" EXPANDED METAL LATH
SCORING
METAL BASE
BASE CLIP 16" O.C.
FILL WITH BROWN PLASTER
ASPHALT TILE FLOOR

2" solid gypsum lath and plaster

A strong, durable partition which offers virtually the same physical characteristics as the typically used solid plaster partition, but has a cost advantage over it.

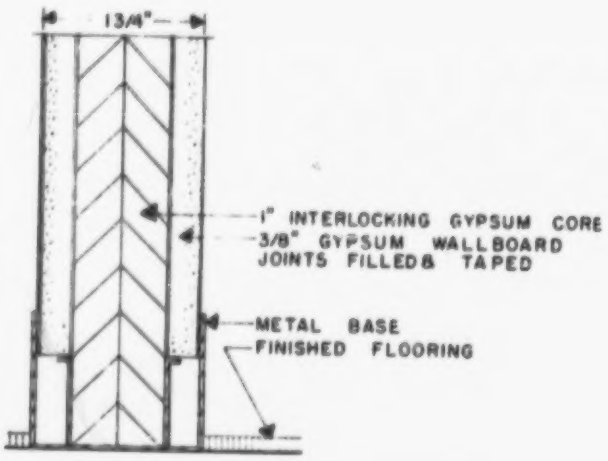
Weight:	16 lbs./sq. ft. - gypsum plaster
Fire rating:	Over 1 hour
T. L.:	37.3 decibels
Cost:	$.68/sq. ft.


2"
LONG-LENGTH LATH 1/2"
GYPSUM PLASTER 3/4"
DOUBLE CLIP
METAL BASE
PLASTER GROUT
FINISHED FLOORING

4-ply gypsum panel—(1" laminated gypsum core—⅜" wallboard laminated vertically each face)

A standard commercial product which has been used successfully in many projects. A similar panel has been used by Metropolitan Life. Results in economies through reduction of installation time.

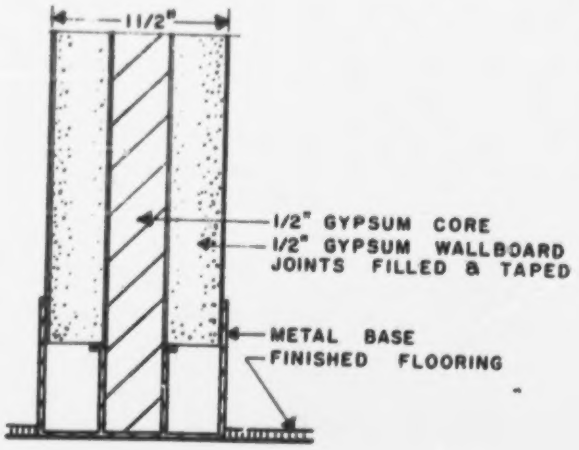
Fire rating:	1 hour
Cost:	$.80/sq. ft.


1 3/4"
1" INTERLOCKING GYPSUM CORE
3/8" GYPSUM WALLBOARD JOINTS FILLED & TAPED
METAL BASE
FINISHED FLOORING

3-ply gypsum panel—(½" gypsum core — 2 sheets of ½" gypsum wallboard laminated vertically to each face. All laminations factory made)

A panel similar to that used in the Pentagon Building, Washington, D.C. Potential use as a prefabricated element indicates more detailed study. Obvious economies easily justifies further investigation.

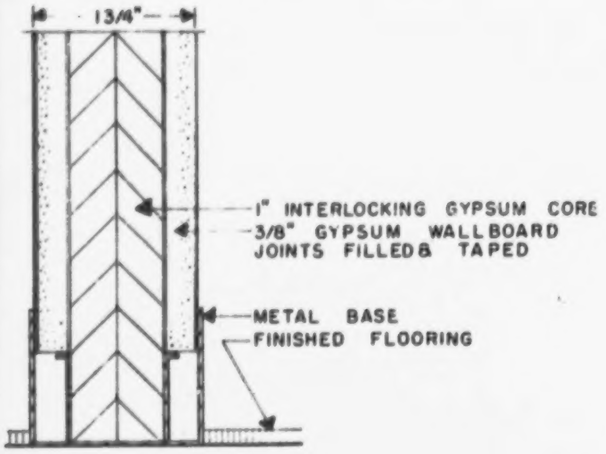
Cost:	$.60/sq. ft.


1 1/2"
1/2" GYPSUM CORE
1/2" GYPSUM WALLBOARD JOINTS FILLED & TAPED
METAL BASE
FINISHED FLOORING

gypsum panel—(1" laminated gypsum -⅜" wallboard laminated vertically face)

ndard commercial product which has been used sfully in many projects. A similar panel has used by Metropolitan Life. Results in economies gh reduction of installation time.

ating:	1 hour
	$.80/sq. ft.


13/4"
1" INTERLOCKING GYPSUM CORE
3/8" GYPSUM WALLBOARD JOINTS FILLED & TAPED
METAL BASE
FINISHED FLOORING

gypsum panel—(½" gypsum core — 2 s of ½" gypsum wallboard laminated cally to each face. All laminations fac- made)

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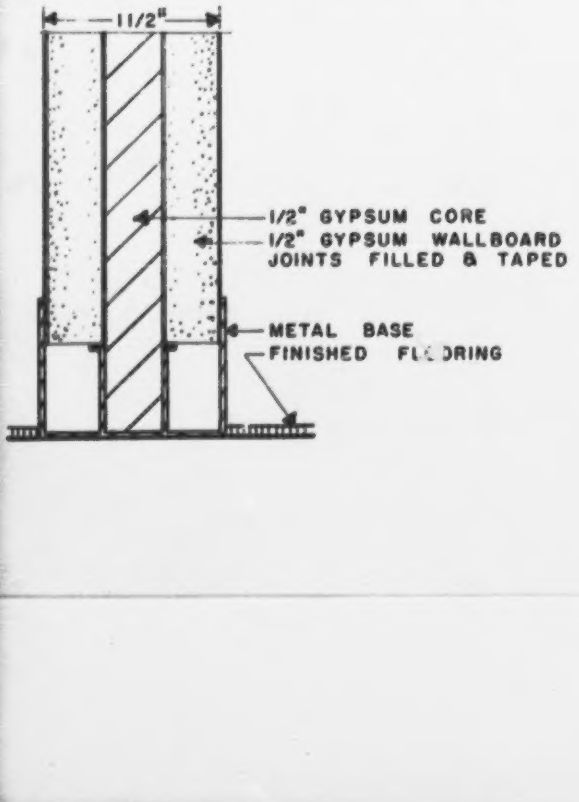
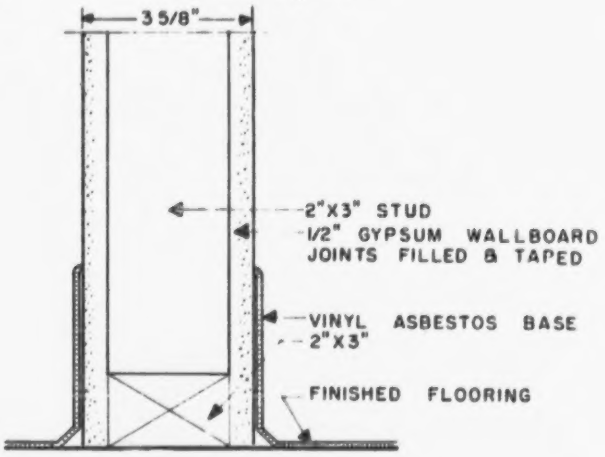
$.60/sq. ft.


11/2"
1/2" GYPSUM CORE
1/2" GYPSUM WALLBOARD JOINTS FILLED & TAPED
METAL BASE
FINISHED FLOORING

½" gypsum wall board on wood studs

At present this panel would not be permitted by the New York City Building Code. If permitted, its cost savings might justify its use. The durability of a single ½" board is questionable for low-income housing.

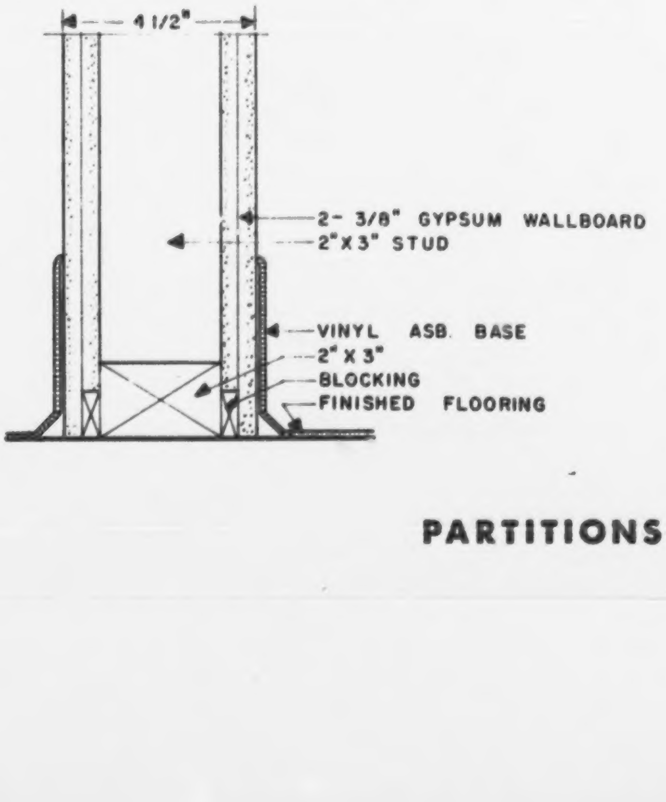
Weight:	5½ lbs./sq. ft.
Fire rating:	40 minutes
T. L.:	34.8 decibels
Cost:	$.51/sq. ft.


3 5/8"
2"X3" STUD
1/2" GYPSUM WALLBOARD JOINTS FILLED & TAPED
VINYL ASBESTOS BASE
2"X3"
FINISHED FLOORING

2-ply gypsum board on wood studs— (2 sheets ⅝" gypsum wall board cemented together - joints filled and covered with tape)

At present not acceptable in Class "A" construction. Used considerably in non-fireproof construction. More durable than single sheet shown above. More economical than presently used solid plaster.

Weight:	8 lbs./sq. ft.
T. L.:	38.8 decibels
Cost:	$.79/sq. ft.


4 1/2"
2- 3/8" GYPSUM WALLBOARD
2"X3" STUD
VINYL ASB. BASE
2" X 3"
BLOCKING
FINISHED FLOORING

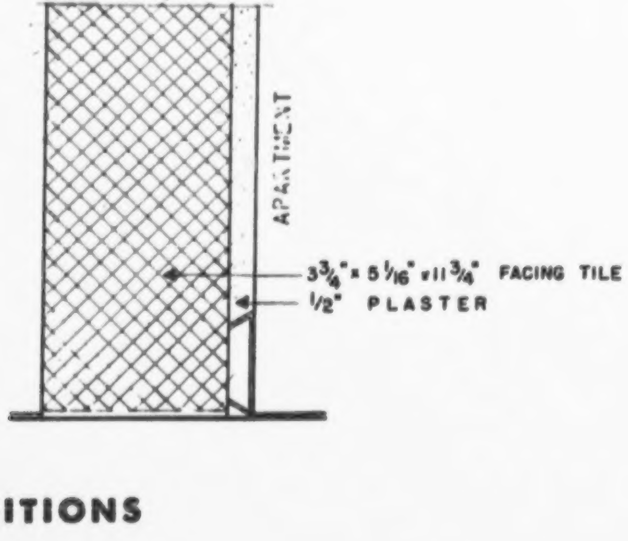
Partitions: Between Public Halls and Apartments

The requirements for partitions between public halls and apartments are few and simple enough to allow the use of a variety of materials other than the presently used 4" glazed structural facing tile. The partitions should be incombustible and have at least a one-hour fire rating. Exposed concrete block may be inadvisable for corridor use, from a maintenance point of view, due to the difficulty in cleaning. However, sprayed surfacing (factory or site applied) on concrete block certainly has proved itself as a durable and easily maintained material and warrants consideration. The same is true for surfacing on concrete block similar to "Marblox" and "Spectra-Glaze."

4" glazed structural facing tile

Glazed surface in corridor and ½" plaster in apartment. Typical partition used in public halls on New York City projects. A very durable material that is easily maintained, but it is a relatively expensive one.

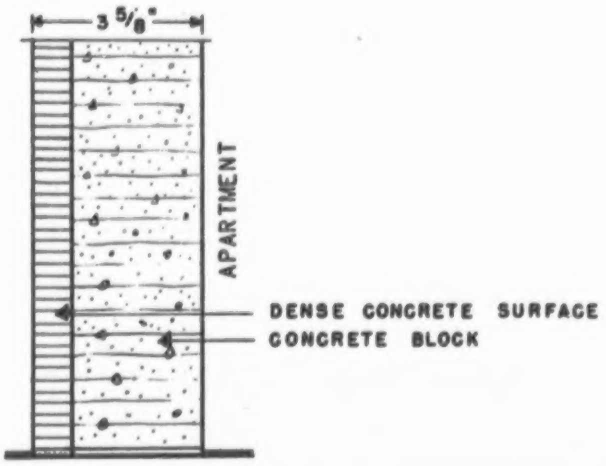
Weight: 27-30 lbs./sq. ft.
Fire rating: 1 hour
Cost: $2.20/sq. ft.



4" faced concrete block

Concrete block faced with applied or integrally surfaced dense concrete. Material resists chemicals and stains to provide easily maintained surface. Example of integral surface is "Marblox" now used by Newark Housing Authority. "Spectra-Glaze," an applied surface, is used in New York City schools.

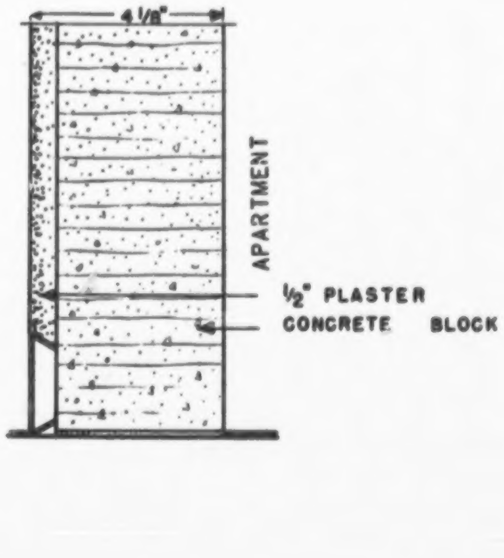
Fire rating: 1 hour
Cost: "Spectra-Glaze" = $.92/sq. ft.
"Marblox" = $.85/sq. ft.



4" concrete block - ½" plaster on corridor

Plaster would offer a fair surface for maintenance. Use of a hard cement plaster is recommended.

Weight: 27 lbs./sq. ft.
Fire rating: 1 hour
Cost: $.83/sq. ft. (slightly higher for hard cement plaster)



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lousing Authority. "Spectra-Glaze," an applied sur-
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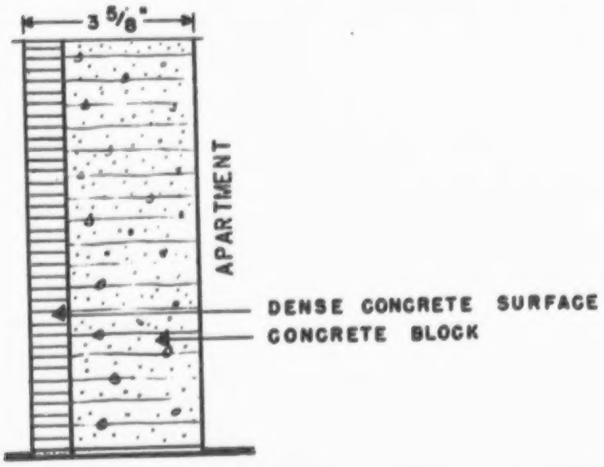
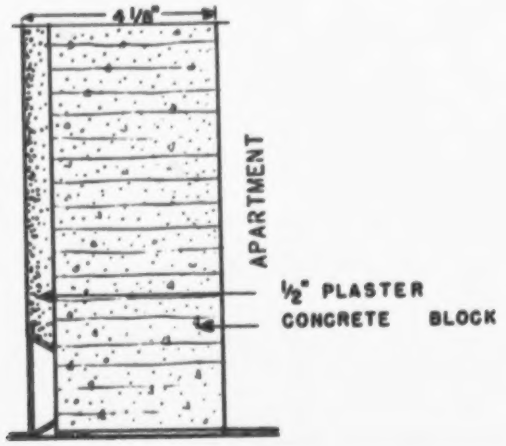

3 5/8"
APARTMENT
DENSE CONCRETE SURFACE
CONCRETE BLOCK

4" concrete block - ½" plaster on corridor

Plaster would offer a fair surface for maintenance. Use of a hard cement plaster is recommended.

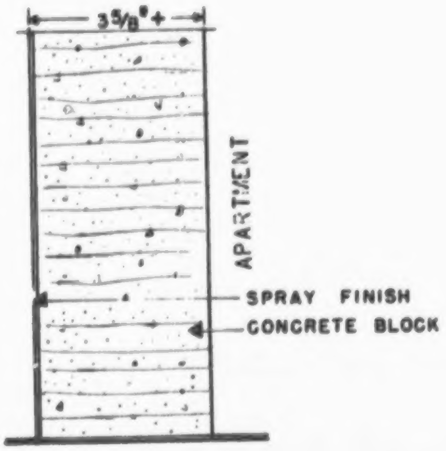
Weight:	27 lbs./sq. ft.
Fire rating:	1 hour
Cost:	\$.83/sq. ft. (slightly higher for hard cement plaster)


4 1/8"
APARTMENT
½" PLASTER
CONCRETE BLOCK

Plastic or cement spray on 4" concrete block

This surfacing on concrete block has been found to resist chemicals and stains so as to provide an easily maintained surface. An example of plastic spray is "Vitra-Spray" used in the Levitt Apartments. Cement-Enamel, a cement spray, has been used internationally.

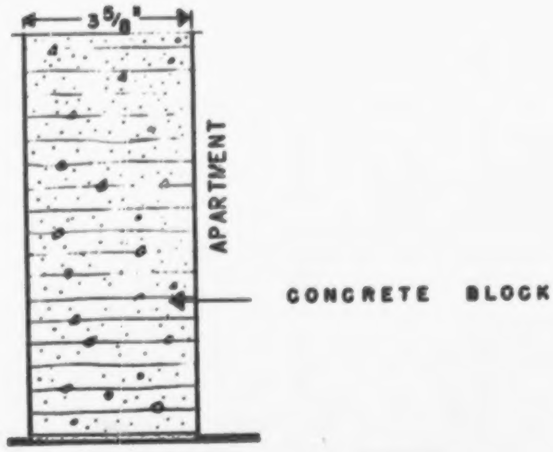
Fire rating:	1 hour	
Cost (incl. block):	Cement spray	\$1.13/sq. ft.
	Plastic spray	\$1.03/sq. ft.


3 5/8"+
APARTMENT
SPRAY FINISH
CONCRETE BLOCK

Exposed 4" concrete block

Used extensively as partitions for schools, residences, and private apartments. Disadvantage of having rough surface which tends to accumulate dirt.

Weight:	21 lbs./sq. ft.
Fire rating:	1 hour
Cost:	\$.52/sq. ft.

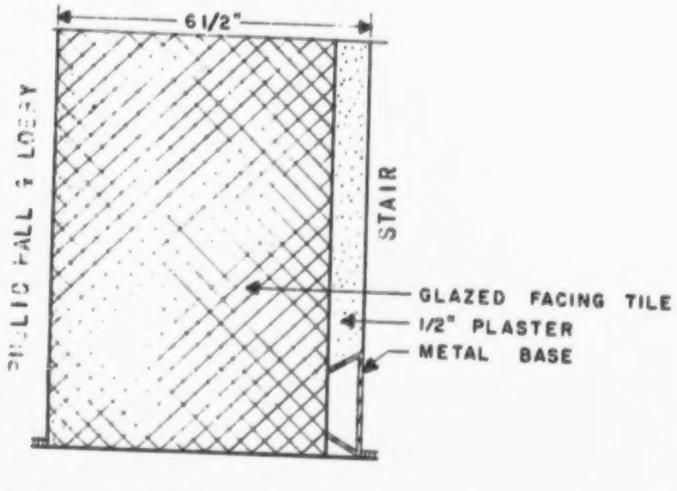

3 5/8"
APARTMENT
CONCRETE BLOCK

Partitions: Between Elevators, Stairs and Halls

6" glazed structural facing tile

Glazed surface in corridor and ½" plaster in stair. Typical partition used in New York City housing projects. This is a very durable material that is easily maintained, but it is a relatively expensive one.

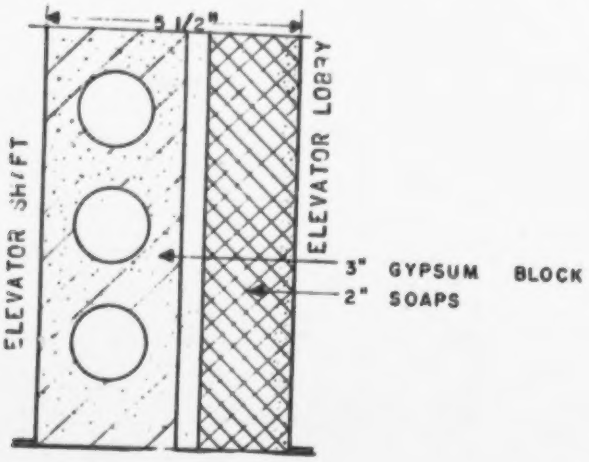
Weight:	41 lbs./sq. ft.
Fire rating:	3 hours
Cost:	$3.80


6 1/2"
PUBLIC HALL & LOBBY
STAIR
GLAZED FACING TILE
1/2" PLASTER
METAL BASE

3" gypsum block and 2" glazed facing tile

Facing tile exposed in elevator lobby. Glazed surface expensive but ideal for maintenance.

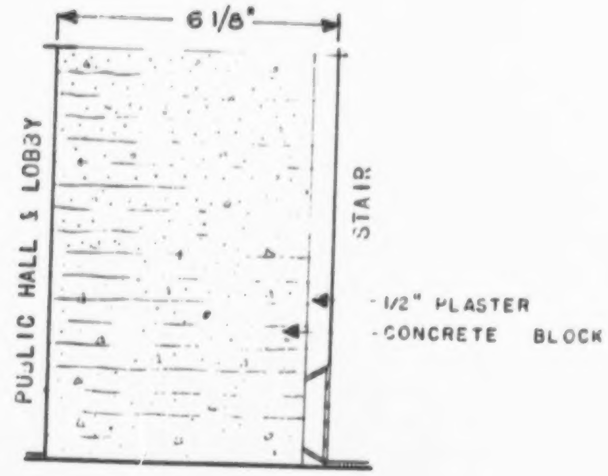
Weight:	26 lbs./sq. ft.
Fire rating:	3 hours
Cost:	$2.50/sq. ft.


5 1/2"
ELEVATOR SHAFT
ELEVATOR LOBBY
3" GYPSUM BLOCK
2" SOAPS

6" concrete block, ½" plaster on corridor

Plaster on hall side would offer a fair surface for maintenance. Use of a hard cement plaster would be better. Exposed concrete satisfactory for stair.

Weight:	35-40 lbs./sq. ft.
Fire rating:	3 hours
Cost:	$.86/sq. ft. (slightly higher for cement plaster)

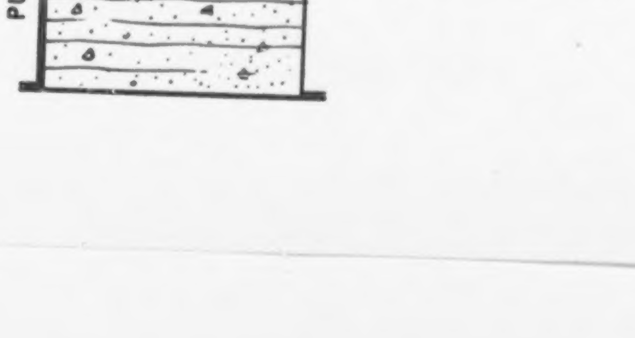

6 1/8"
PUBLIC HALL & LOBBY
STAIR
1/2" PLASTER
CONCRETE BLOCK

Plastic or cement spray on 6" concrete block

This surfacing on concrete block has been found to resist chemicals and stains so as to provide an easily maintained surface. Spray used may be similar to "Vitra-Spray" (plastic) or Cement-Enamel.

Fire rating: 3 hour

Cost (incl. block): "Vitra-Spray" = $1.05/sq. ft.
Cement-Enamel = $1.15/sq. ft.


5 5/8"
PUBLIC HALL & LOBBY
STAIR
CONCRETE BLOCK
SPRAY SURFACE ON ONE OR TWO SIDES

Fac
Con
face
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have
Fire
Cost

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ating: 3 hours
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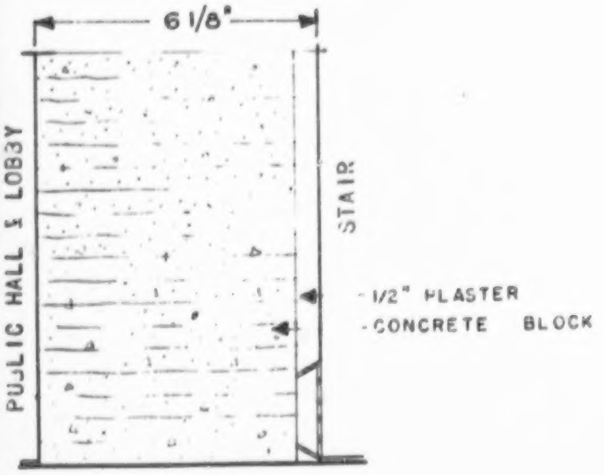
6 1/8"
PUBLIC HALL & LOBBY
STAIR
1/2" PLASTER
CONCRETE BLOCK

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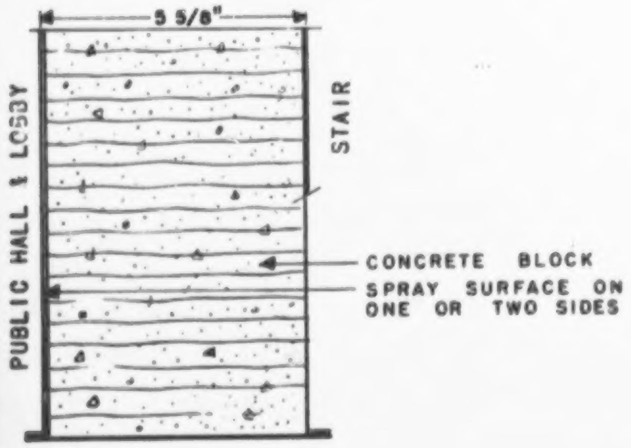
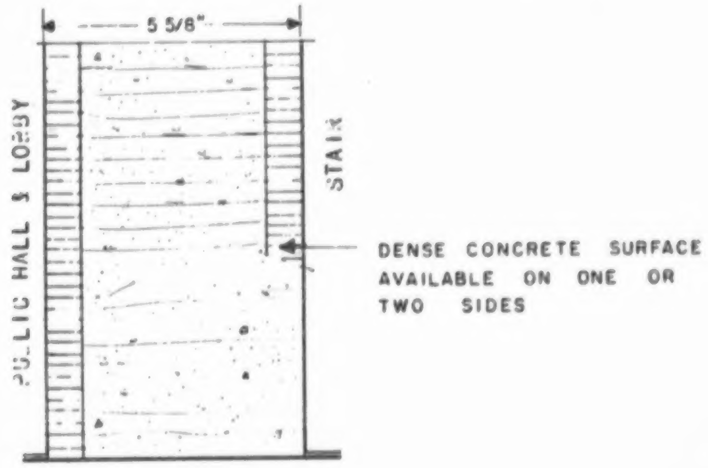
(incl. block): "Vitra-Spray" =$1.05/sq. ft.
Cement-Enamel=$1.15/sq. ft.


5 5/8"
PUBLIC HALL & LOBBY
STAIR
CONCRETE BLOCK
SPRAY SURFACE ON ONE OR TWO SIDES

Faced concrete block (6")

Concrete block faced with applied or integrally surfaced dense concrete. Material resists chemicals and stains to provide an easily maintained surface. Two examples are "Marblox" and "Spectra-Gaze." May have one or two finished surfaces.

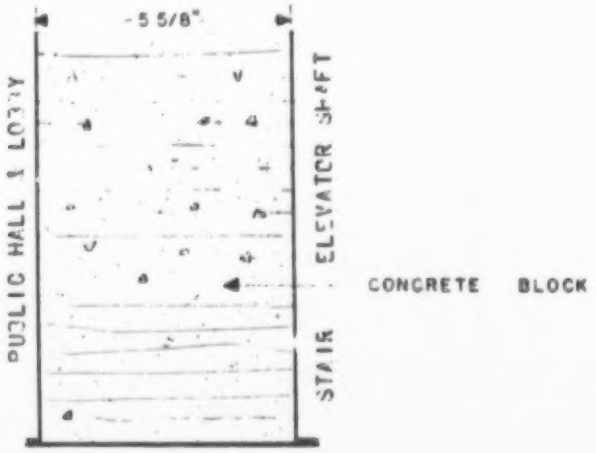
Fire rating: 3 hour
Cost: "Spectra-Glaze"—1 side =$1.02
2 sides=$1.45
"Marblox" —1 side =$ .95
2 sides=$1.35


5 5/8"
PUBLIC HALL & LOBBY
STAIR
DENSE CONCRETE SURFACE AVAILABLE ON ONE OR TWO SIDES

Exposed 6" concrete block

Used extensively for partitions in schools, residences, and private apartments. Disadvantage, for corridor use, is that it has a rough surface that tends to collect dirt.

Weight: 30-35 lbs./sq. ft.
Fire rating: 3 hour
Cost: $.55/sq. ft.


5 5/8"
PUBLIC HALL & LOBBY
ELEVATOR SHAFT
STAIR
CONCRETE BLOCK

Partitions: Between Apartments

The requirements for partitions between apartments are based primarily on fire protection and sound reduction. The partitions should be incombustible and should have at least a one-hour fire rating.

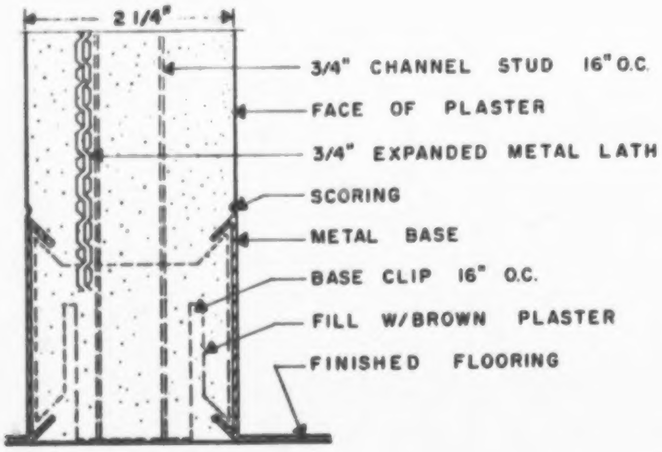
A noise reduction of at least 40 decibels in the 256-1024 cycles/second range is required by the Division of Housing.

There are many partitions that meet these requirements, but the following are those that would prove to be the most economical.

2¼" solid plaster

Typical plaster partition used between apartments in New York City projects. Advantages are that it is a thin and lightweight partition.

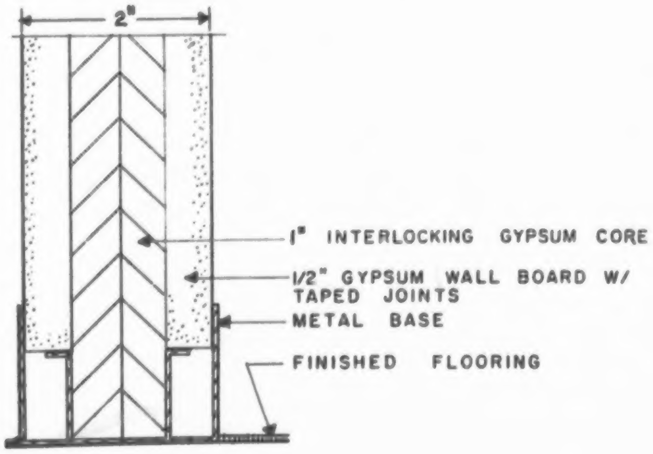
Weight:	20 lbs./sq. ft. (gypsum plaster)
Fire rating:	1 hour
T. L.:	About 40 decibels
Cost:	$.97/sq. ft.


2 1/4"
3/4" CHANNEL STUD 16" O.C.
FACE OF PLASTER
3/4" EXPANDED METAL LATH
SCORING
METAL BASE
BASE CLIP 16" O.C.
FILL W/BROWN PLASTER
FINISHED FLOORING

4-ply gypsum board—(1" laminated gypsum core—½" wall board laminated vertically each face)

Standard commercial product used successfully in many projects. A similar panel has been used in Metropolitan Life projects. Its use results in economies through reduction of installation time.

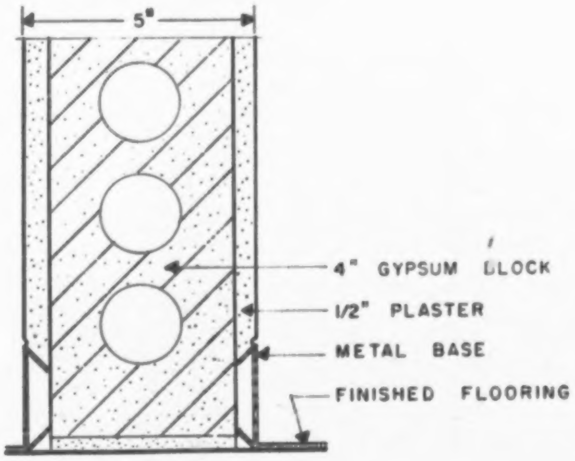
Weight:	8½ lbs./sq. ft.
Fire rating:	2 hours
T. L.:	41 decibels
Cost:	$.80/sq. ft.


2"
1" INTERLOCKING GYPSUM CORE
1/2" GYPSUM WALL BOARD W/ TAPED JOINTS
METAL BASE
FINISHED FLOORING

½" plaster on 4" gypsum block

Typical partition used in fireproof construction. Lightweight, durable, and because of large size, 4 x 12 x 30, easily erected.

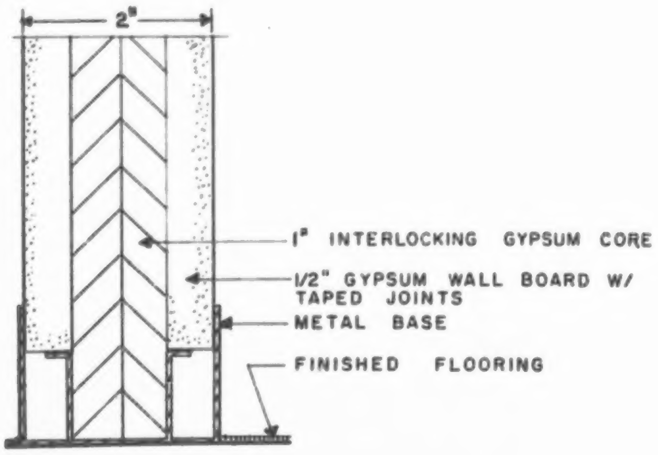
Weight:	23.4 lbs./sq. ft.
Fire rating:	4 hours
T. L.:	41.6 decibels
Cost:	$.90/sq. ft.


5"
4" GYPSUM BLOCK
1/2" PLASTER
METAL BASE
FINISHED FLOORING

4-ply gypsum board—(1" laminated gypsum core—½" wall board laminated vertically each face)

Standard commercial product used successfully in many projects. A similar panel has been used in Metropolitan Life projects. Its use results in economies through reduction of installation time.

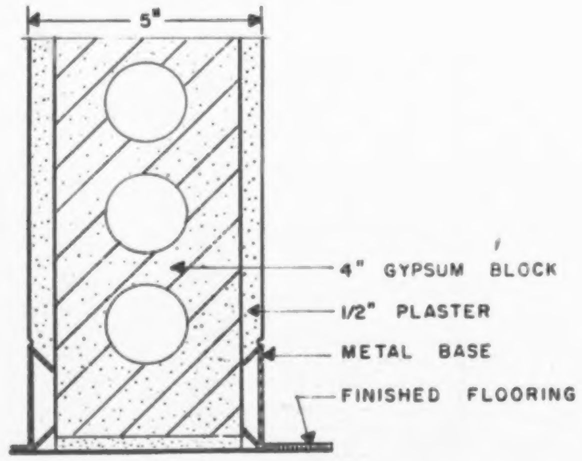
Weight:	8½ lbs./sq. ft.
Fire rating:	2 hours
T. L.:	41 decibels
Cost:	$.80/sq. ft.


2"
1" INTERLOCKING GYPSUM CORE
1/2" GYPSUM WALL BOARD W/ TAPED JOINTS
METAL BASE
FINISHED FLOORING

½" plaster on 4" gypsum block

Typical partition used in fireproof construction. Lightweight, durable, and because of large size, 4 x 12 x 30, easily erected.

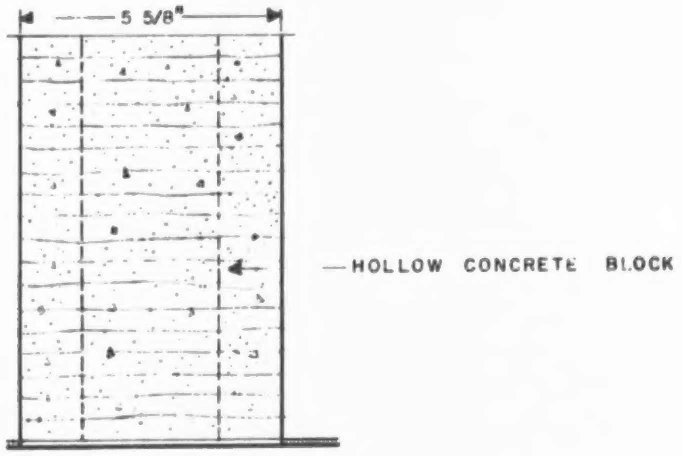
Weight:	23.4 lbs./sq. ft.
Fire rating:	4 hours
T. L.:	41.6 decibels
Cost:	$.90/sq. ft.


5"
4" GYPSUM BLOCK
1/2" PLASTER
METAL BASE
FINISHED FLOORING

Exposed 6" concrete block (alternate with sprayed cement or plastic)

Used extensively as partitions for schools, residences and private apartments. Disadvantage of having rough surface which tends to accumulate dirt. Spray finish would eliminate this. Example: Levitt Apartments - N.Y.C.

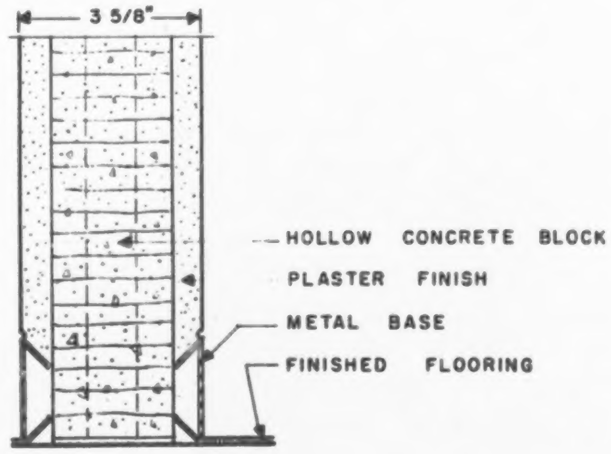
Weight:	30-35 lbs./sq. ft.
Fire rating:	3 hours
T. L.:	40 decibels
Cost:	$.55/sq. ft.


5 5/8"
HOLLOW CONCRETE BLOCK

Plaster on 3" concrete block

Durable and easily maintained surface. High noise reduction coefficient for use as apartment separation.

Weight:	30 lbs./sq. ft.
Fire rating:	1 hour
T. L.:	45 decibels
Cost:	$1.12/sq. ft.


3 5/8"
HOLLOW CONCRETE BLOCK
PLASTER FINISH
METAL BASE
FINISHED FLOORING

2 Comparative Graphs For Partitions

On this page will be found, in graph form, a comparative analysis of the preceding pages. The purpose is to give the reader a comparative cost picture at a quick glance. Although recommended partitions are designated, it should always be remembered that certain criteria govern the selection of a suitable material for each specific design problem. At times economy alone is the governing factor, while in other instances it is maintenance.

The primary purpose of this section is to show that there are alternate methods of constructing partitions, other than those adhered to by the Division of Housing, that will result in considerable economies.

Listed below are the approximate square foot requirements for the project previously mentioned at the introduction of this Chapter:

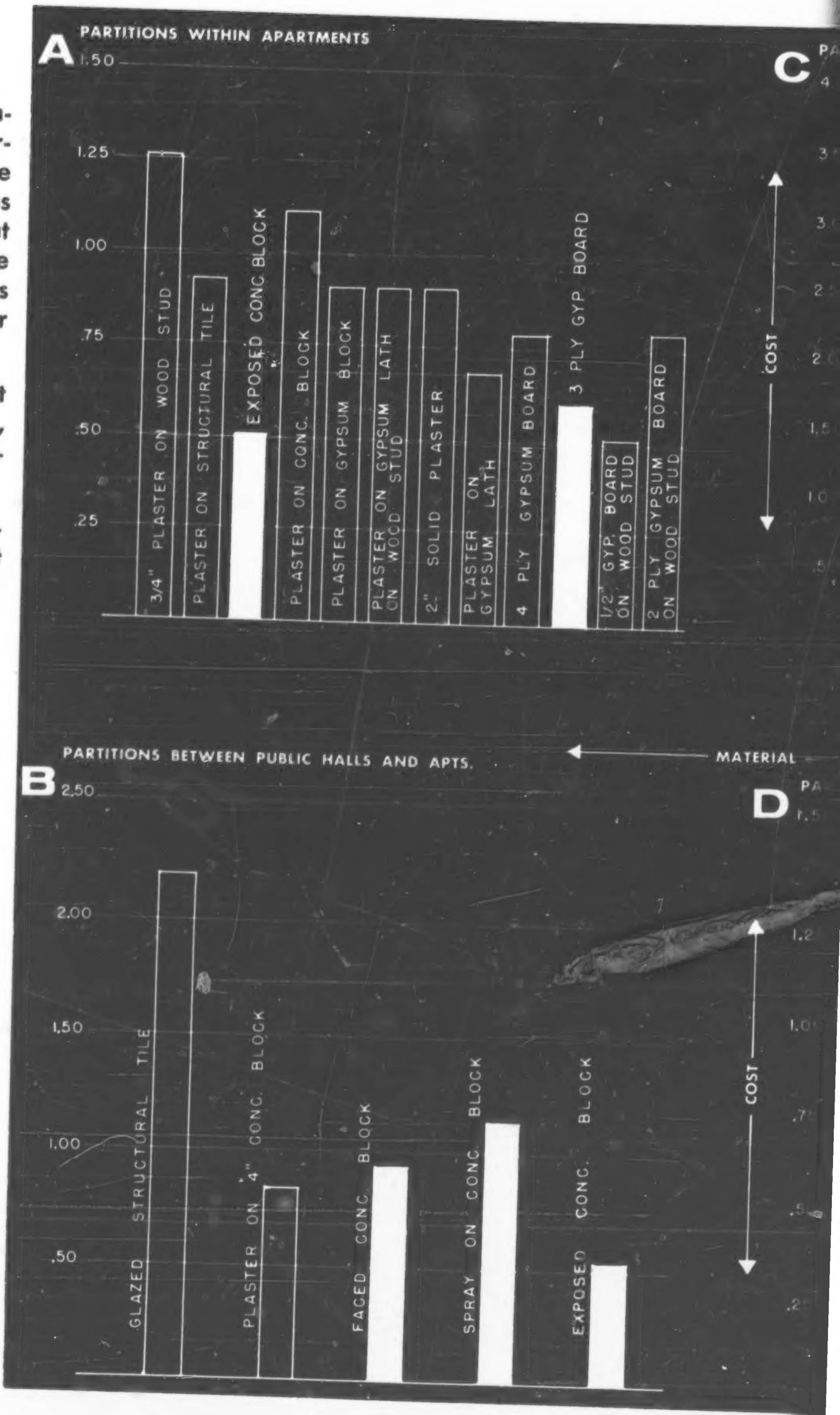
1. Partitions within apartments:
   Approximately 1,250,000 sq. ft.

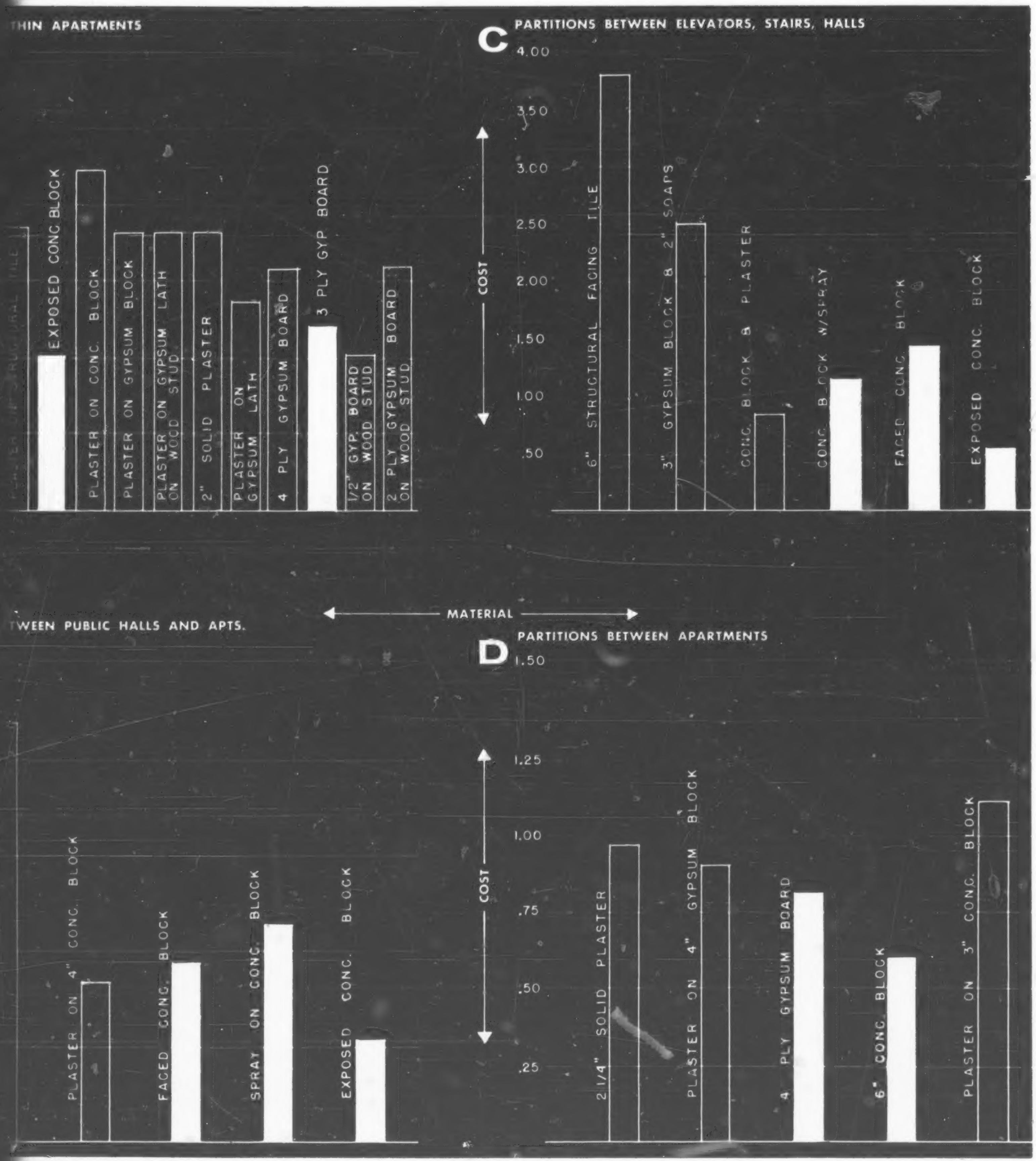
2. Partitions between apartments and halls:
   Approximately 300,000 sq. ft.

3. Partitions between elevators, stairs and halls:
   Approximately 150,000 sq. ft.

4. Partitions between apartments:
   Approximately 250,000 sq. ft.

By using these figures and the costs shown on the graphs, an overall cost savings may be readily arrived at. An example would be to take the cost differential between glazed structural tile and sprayed concrete block ($2.20 − $1.03 = $1.17) and multiply by the applicable square foot requirement (300,000 sq. ft.) and arrive at a project cost savings ($351,000) for this particular item. Note that graph columns in white denote materials recommended for their economy.





PARTITIONS — CHART

3 Finishes

The second group of interior elements to be examined consists of floor, ceiling and bathroom finishes. In some of the areas investigated a large immediate saving may be realized; while in others, the savings may only be brought about by a code revision permitting use of suggested finishes.

The purpose of this section is again cost reduction, but it differs from the previous section in that the savings are not likely to be very large. In some cases the savings are very definite ones, but since they pertain to small areas the total cost reduction is small. An example of this is found in bathroom wall finishes. In other cases, the savings are questionable and may fluctuate. An example of this is in the finishing of concrete slabs for ceilings. Although this pertains to a very large area, the cost differential between various methods is small and reversible. For this reason alternate bidding by contractors on this item is suggested to permit pricing flexibility.

The costs used are average unit costs for low-cost housing in New York City (Summer 1957) and will vary somewhat depending on color selections, amount of straight or corner work, and the condition of the market at bid time.

Finishes: Floors

A variety of floor finishes are included to show possible cost savings available with a change in materials. As with other construction materials used in low-income housing projects, selection of floor finishes has become stereotyped. To have the most economical floor, the concrete slab would be left exposed and untreated. Of course, this would not be satisfactory due to its coarseness and tendency to powder. Application of a dustproof covering would be an additional benefit, but the application would be a frequent maintenance problem.

A more satisfactory solution would be the addition of a concrete hardener to the structural slab. This would result in a suitable finish for low-income projects. If a more resilient finish is desired asphalt tile, which is currently used on almost all low-income projects in New York City, would be an economical, low first-cost solution.

Vinyl-asbestos would be a better material where excessive wear necessitates constant replacement of asphalt tile. A five-year use period would see the recovery of the additional first cost, due to low replacement and ease of maintenance.

Another immediate cost savings of approximately $1.20/sq. ft. would be realized by substituting vinyl tile for quarry tile in elevator lobbies.

3A

Exposed concrete slab with hardener

Cost (hardener only): $.07/sq. ft.

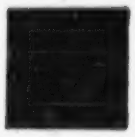
A mixture of tough wear-resisting aggregates are combined with mineral oxides. Applied to concrete slab, as a dust coat, with a steel float or trowel, as floor is laid. Combines integrally with the cement, producing an extremely hard wear-resisting floor finish with a uniformly colored surface. Generally chemical and erosion resistant, reduces dusting. Disadvantage of having no resilience.

Exposed concrete with dustproofing

Cost (dustproofing only): $.06/sq. ft. ⅛" penetration

A liquid is applied to concrete surface, changing soft granular topping into a dense mass which resists severe wear and abrasion without dusting. Disadvantage is that it is similar to a paint coat and must be repeated at frequent intervals.

Quarry tile



6" x 6" x ½" red - ⅜" joint
Cost: $1.80/sq. ft.

This hard-burned vitreous shale is now used in elevator lobbies of many New York City projects. Low absorption and a high resistance to abrasion and acid. Has a low maintenance and a long life. Principal disadvantage is its very high cost.

oncrete slab with hardener

ner only): $.07/sq. ft.

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vith mineral oxides. Applied to concrete
dust coat, with a steel float or trowel, as
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concrete with dustproofing

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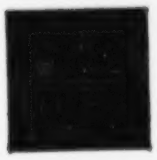
applied to concrete surface, changing soft
opping into a dense mass which resists
ar and abrasion without dusting. Disad-
that it is similar to a paint coat and must
ed at frequent intervals.

tile

½" red - ⅜" joint
80/sq. ft.

-burned vitreous shale is now used in eleva-
es of many New York City projects. Low
on and a high resistance to abrasion and
s a low maintenance and a long life. Prin-
advantage is its very high cost.

Asphalt tile



9" x 9" x ⅛"
"B" grade
Cost: $.14/sq. ft.

Grease resistance—poor
Surface alkali resistance—excellent
Solvent resistance—poor
Durability—excellent
Ease of maintenance—good

Presently used extensively in all New York State housing projects. Initial low cost and, for areas of minimum traffic, low maintenance.

Vinyl-asbestos tile

9" x 9" x ⅛"
Cost: $.32/sq. ft.

Grease resistance—excellent
Surface alkali resistance—excellent
Solvent resistance—excellent
Durability—superior
Ease of maintenance—superior

Although more expensive than asphalt tile, vinyl-asbestos tile will stand up better under heavy traffic. It has been estimated that vinyl-asbestos tile will, because of better maintenance and less frequent replacement, recover the extra cost over asphalt tile within a five-year period.

Vinyl tile

9" x 9" x ⅛"
Standard grade
Cost: $.60/sq. ft.

Grease resistance—superior
Surface alkali resistance—excellent
Solvent resistance—excellent
Durability—superior
Ease of maintenance—superior

Use of this tile as a substitute for quarry tile would result in a considerable cost savings. Vinyl tile is a satisfactory substitute fulfilling all necessary requirements.

Finishes: Ceilings

A possible area for a very small cost saving may be found in the finishing of the structural slab for ceilings. There are a few commonly used methods of finishing, and a few that have potential use. It was found in this study that the more commonly used methods are very similar in their costs. Due to this fact, it has been felt advisable to recommend that all projects have alternate bids submitted for:

A. Grinding concrete

B. ⅛" thin-coat of plaster

C. Stippled masonry paint on rough concrete

A very basic savings may be realized by leaving the raw concrete untreated, but this is certain to draw severe criticism.

Grinding exposed concrete

Cost: $.08/sq. ft.

Most common method of finishing ceilings in
come housing projects. Slab is ground to rem
protrusions, drips, snots, etc., and all honey
areas are filled. This method results in a sma
form finish. Grinding is competitive with pl
and painting.

⅛" thin coat of plaster

Cost: $.08/sq. ft.

A ready-mixed material consisting of conv
plastering ingredients, other than sand, th
mixed with water to the proper consistency,
applied and trowelled on the underside of t
crete slab to a one-coat thickness of ⅛".

This finishing method has been used succes
many projects including numerous housing
Its price is definitely competitive with grindi
with painting.

Taped formwork

Cost: $.12/sq. ft.

Taping the joints in plywood formwork ha
suggested as a method of reducing the usual
after the slab has been poured and forms r
If properly done, it would eliminate any drip
joints. This method would necessitate ve
supervision.

Textured formliners

Cost: $.15/sq. ft.

Rubber and plastic formliners are now avail
use in concrete construction. Their use wo
eliminate the need for further concrete
Rubber formliners with bold patterns have b
in Europe with much success. Formliners
paratively low in initial cost and reusable
handled carefully.

Stipple-texture paint

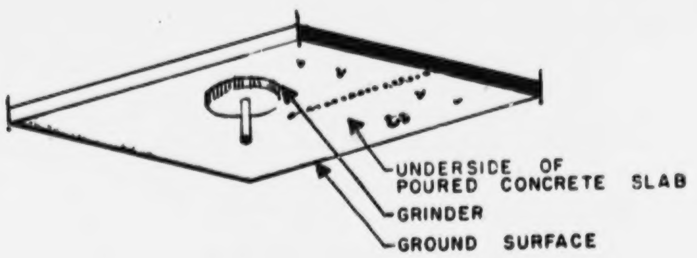
Cost: $.08/sq. ft.

Made of latex and resins this paint is tou
plaster and more durable than ordinary
primers, sealers, or undercoats are necessar
this material eliminates the necessity of
finish treatment to the rough concrete slab.

nding exposed concrete

: $.08/sq. ft.

t common method of finishing ceilings in low-in-e housing projects. Slab is ground to remove all rusions, drips, snots, etc., and all honeycombed as are filled. This method results in a smooth uni-n finish. Grinding is competitive with plastering painting.

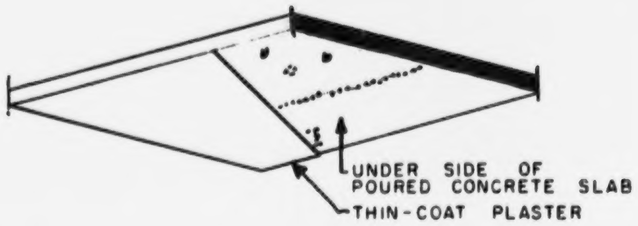

UNDERSIDE OF POURED CONCRETE SLAB
GRINDER
GROUND SURFACE

thin coat of plaster

t: $.08/sq. ft.

eady-mixed material consisting of conventional stering ingredients, other than sand, that are ed with water to the proper consistency. This is lied and trowelled on the underside of the con-e slab to a one-coat thickness of ⅛".

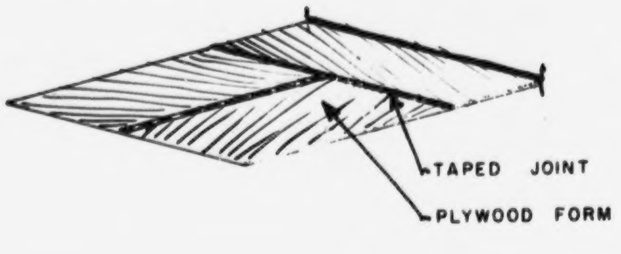
finishing method has been used successfully in ny projects including numerous housing projects. price is definitely competitive with grinding and n painting.


UNDER SIDE OF POURED CONCRETE SLAB
THIN-COAT PLASTER

ped formwork

st: $.12/sq. ft.

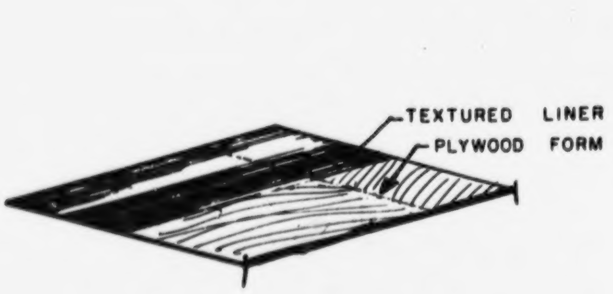
ing the joints in plywood formwork has been gested as a method of reducing the usual finishing er the slab has been poured and forms removed. properly done, it would eliminate any dripping at nts. This method would necessitate very close pervision.


TAPED JOINT
PLYWOOD FORM

xtured formliners

st: $.15/sq. ft.

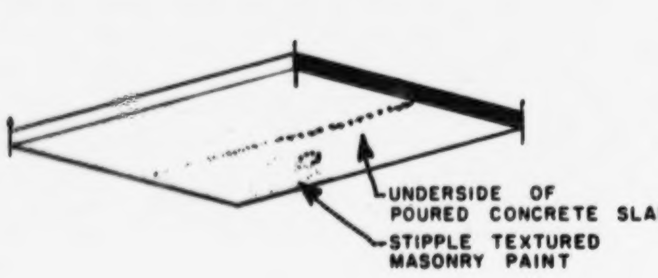
bber and plastic formliners are now available for e in concrete construction. Their use would help minate the need for further concrete finishing. bber formliners with bold patterns have been used Europe with much success. Formliners are com-ratively low in initial cost and reusable often, if ndled carefully.


TEXTURED LINER
PLYWOOD FORM

ipple-texture paint

st: $.08/sq. ft.

ade of latex and resins this paint is tougher than aster and more durable than ordinary paint. No imers, sealers, or undercoats are necessary. Use of is material eliminates the necessity of any other ish treatment to the rough concrete slab.


UNDERSIDE OF POURED CONCRETE SLAB
STIPPLE TEXTURED MASONRY PAINT

ishes: Bathroom Walls

ough bathroom wall finishes represent only a
ll portion of the total area in an apartment, these
hes are usually of a very expensive material. To
r credit, it must be said that they are very durable.
e Division of Housing desires to reduce the cost of
struction, even in small amounts, it is probable
a reasonable amount may be saved in a substi-
on of bathroom finishes.

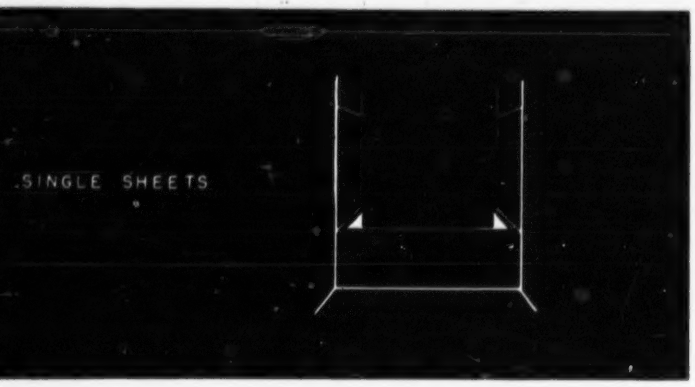
present there is approximately 40 sq. ft. of wall
a, per bathroom, that is finished with ceramic tile.
amic tile bath tub enclosures are, of course, highly
rable, but can hardly be justified because of high
. As will be shown, there are a variety of substi-
materials that are much more economical.

plaster with laminated plastic finish rmica, Consoweld, etc.)

minate surfacing material that resists stains, acids,
lies and is water resistant. It is virtually main-
nce free.

ter cost:	$ .85
tic cost:	4.73
l	$5.58/sq. ft.

cost is exceptionally high but it is for convention-
se of the material. A manufacturer has offered a
tub encloseure for $58. Adding a 25% overhead
profit, we get $72.50 or $1.80/sq. ft. instead of
73.

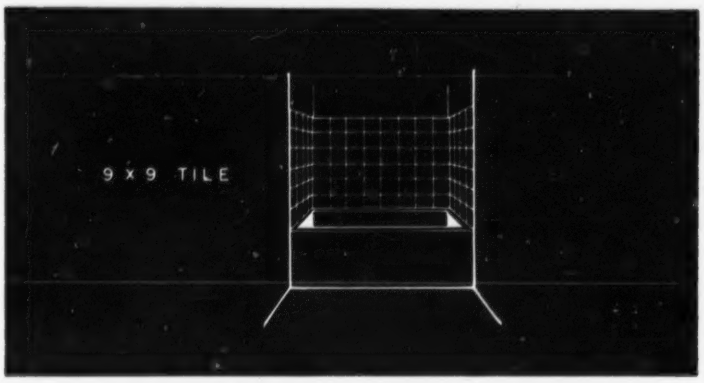


2" plaster wall finished with asphalt tile

9" x 9" x ⅛"—"B" grade w/metal trim

Plaster cost:	$ .85
Tile cost:	.18
Total	$1.03

This wall is not acceptable by present standards, but certainly bears more examination because of its comparatively low cost. Its use with proper adhesive should present a durable material.

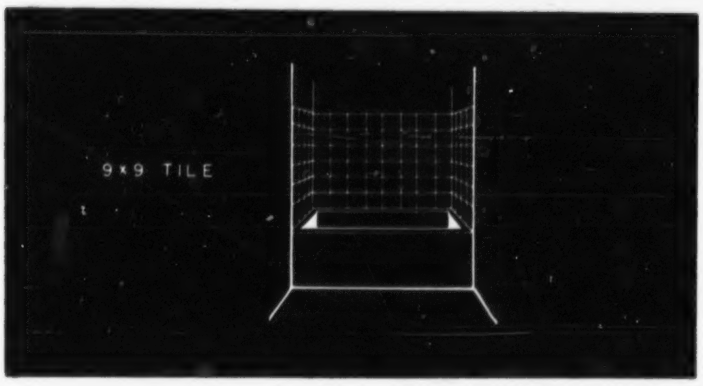


2" plaster finished with vinyl tile

9" x 9" x ⅛"—standard gauge vinyl tile w/metal trim

Plaster cost:	$ .85
Tile cost:	.80
Total	$1.65

A somewhat theoretical wall material. A very durable and maintenance free tile that has proven itself as a floor covering. Certainly its potential use should be examined.



2" pl

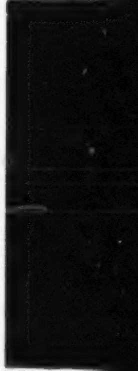
4" x 4"–
Plaster
Tile co
Total

An ine
waterpr
used w
approv

2" pl

Ceramic
4¼" x 4
Plaster
Tile cos
Total

This is a
mum o
compos
of a fir
stains.



ster wall finished with asphalt tile

x ⅛"—"B" grade w/metal trim
cost: $ .85
t: .18
$1.03

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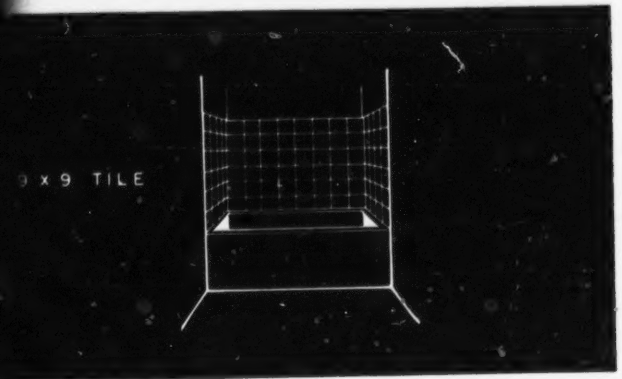
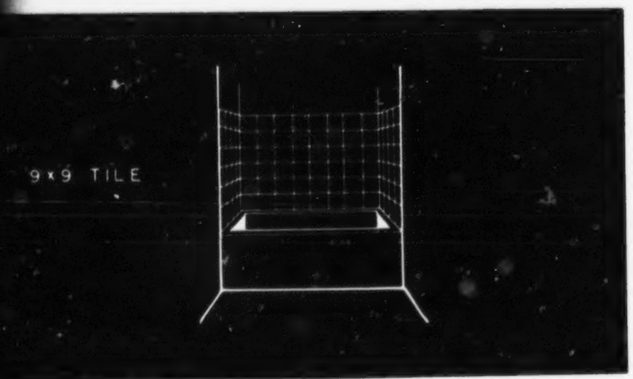


laster finished with vinyl tile

" x ⅛"—standard gauge vinyl tile w/metal trim
r cost: $ .85
ost: .80
$1.65

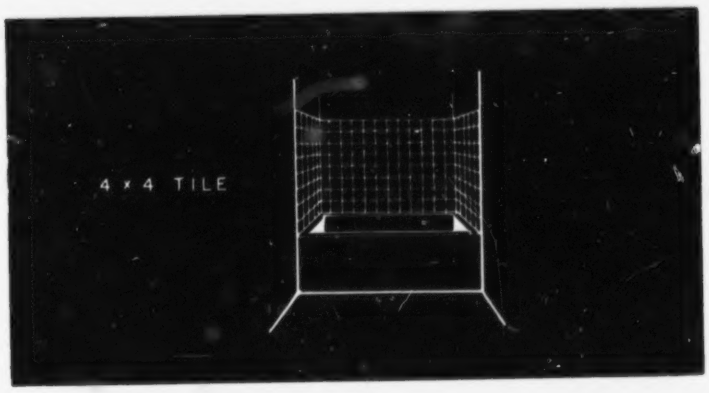
ewhat theoretical wall material. A very durable
aintenance free tile that has proven itself as a
covering. Certainly its potential use should be
ned.



2" plaster finished with plastic wall tile

4" x 4"—standard grade field tile
Plaster cost: $ .85
Tile cost: 1.10
Total $1.95/sq. ft.

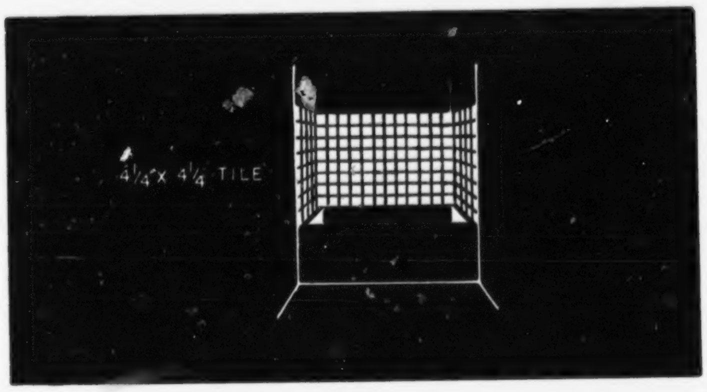
An inexpensive and durable wall covering that is waterproof. It is made of polystyrene. It has been used widely as a bathroom wall covering and is approved by the F.H.A.



2" plaster wall finished with ceramic tile

Ceramic glazed semi-matt wall tile, standard grade, 4¼" x 4¼"
Plaster cost: $ .85
Tile cost: 1.60
Total $2.45/sq. ft.

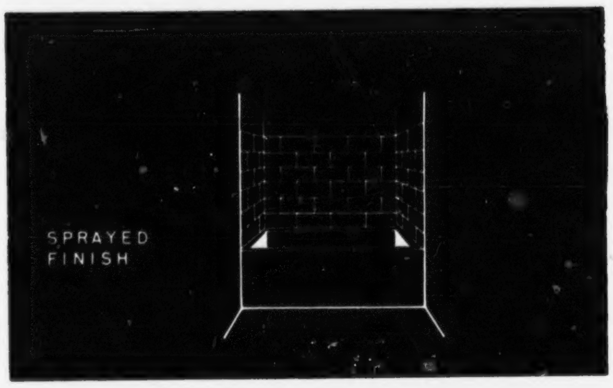
This is a very durable material that requires a minimum of maintenance. It has an impervious finish composed of ceramic materials fused on the surface of a fired clay body. The surface will not absorb stains. It is used in almost all housing projects.



Plastic or cement spray on 3" concrete block

Cost (incl. block): Plastic spray = $1.00/sq. ft.
Cement spray = $1.10/sq. ft.

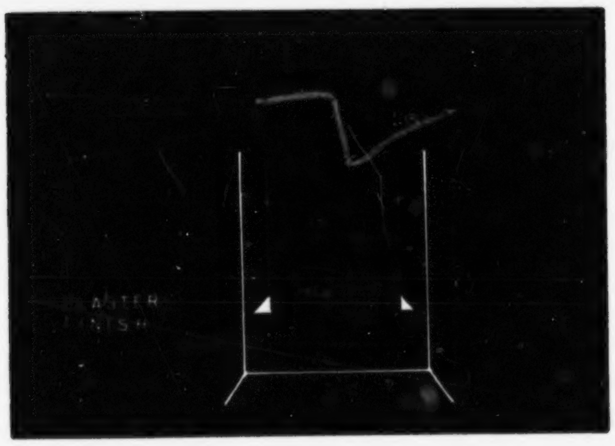
This surfacing on concrete block has been found to resist chemicals and stains so as to provide an easily maintained surface. Plastic spray was effectively used in the bathrooms of the Levitt Apartments in Queens, N.Y.C.



Portland cement-lime plaster finish on 2" plaster wall

Cost: Approximately $1.19

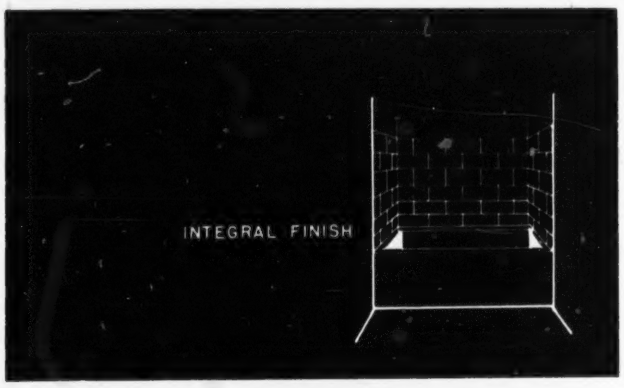
Portland cement-lime plaster is used in areas subject to high moisture conditions. Its use would alleviate the necessity for applying a finishing material over the plaster wall. Not as durable or as maintenance free as other materials but certainly an economical solution to the problem. It has been used effectively in many similar installations.



Faced concrete block (4")

Cost: "Spectra-Glaze" = $.92/sq. ft.
"Marblox" = $.85/sq. ft.

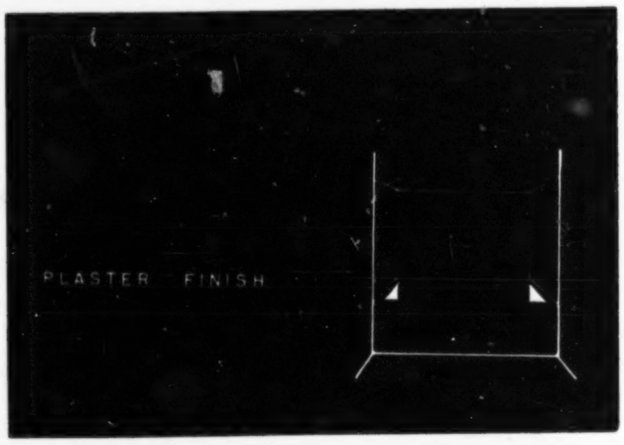
Concrete block faced with applied or integrally surfaced dense concrete. Material resists chemicals and stains to provide an easily maintained surface. Two examples are "Marblox" and "Spectra-Glaze." The very definite cost savings here should be examined further.



Paint coat of semi-gloss enamel on 2" plaster wall

Plaster cost:	$.92
Enamel cost:	.07
Total	$.99

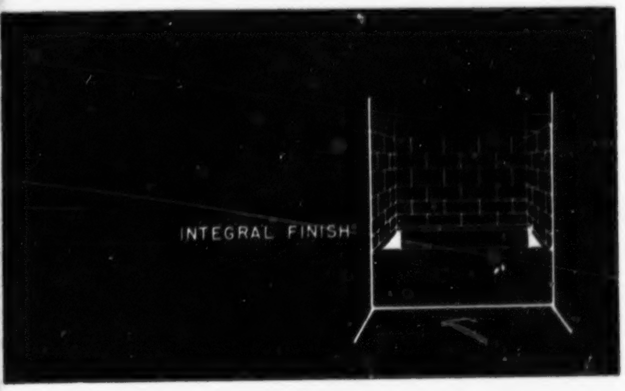
This certainly offers, by far, the greatest economy as a bathroom wall finish. Its very low initial cost may make up for periodic maintenance. This recommendation was offered in a cost reduction report by the New York City Housing Authority.



Faced concrete block (4")

Cost: "Spectra-Glaze" = $.92/sq. ft.
"Marblox" = $.85/sq. ft.

Concrete block faced with applied or integrally surfaced dense concrete. Material resists chemicals and stains to provide an easily maintained surface. Two examples are "Marblox" and "Spectra-Glaze." The very definite cost savings here should be examined further.



Paint coat of semi-gloss enamel on 2" plaster wall

Plaster cost:	$.92
Enamel cost:	.07
Total	$.99

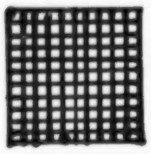
This certainly offers, by far, the greatest economy as a bathroom wall finish. Its very low initial cost may make up for periodic maintenance. This recommendation was offered in a cost reduction report by the New York City Housing Authority.

PLASTER FINISH

Finishes: Bathroom Floors

The presently used materials for these surfaces, although functionally ideal, are economically unjustfied. A variety of reasonable cost reducing substitutes are suggested. Again the total project savings will be proportionately small because of the small area under consideration. The floor finish, at present, is ceramic mosaic tile. This covers an area of approximately 20 sq. ft. A very economical substitute floor covering would be asphalt tile. Use of asphalt tile would amount to a savings of approximately $25/bathroom or $40,000 in a 1600 unit project.

Ceramic mosaic tile

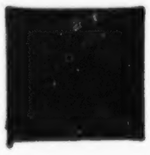


Standard grade ¾" square one color
Cost: $1.40/sq. ft.

Presently used bathroom floor finish. Covers an area of approximately 20 sq. ft. A very durable and maintenance free flooring.

A highly desirable finish, but one that should be eliminated because of its high cost. Acceptance of this material has become too stereotyped.

Asphalt tile



9" x 9" x ⅛"—"B" grade
Cost: $.14/sq. ft.

Presently used extensively in all New York State Housing projects for rooms other than baths. It is a durable floor covering with a relatively good ease of maintenance. Because of its low initial cost, its use certainly should be examined. Its use has been recommended by the New York City Housing Authority for bathrooms.

4 Comparative Graphs For Finishes

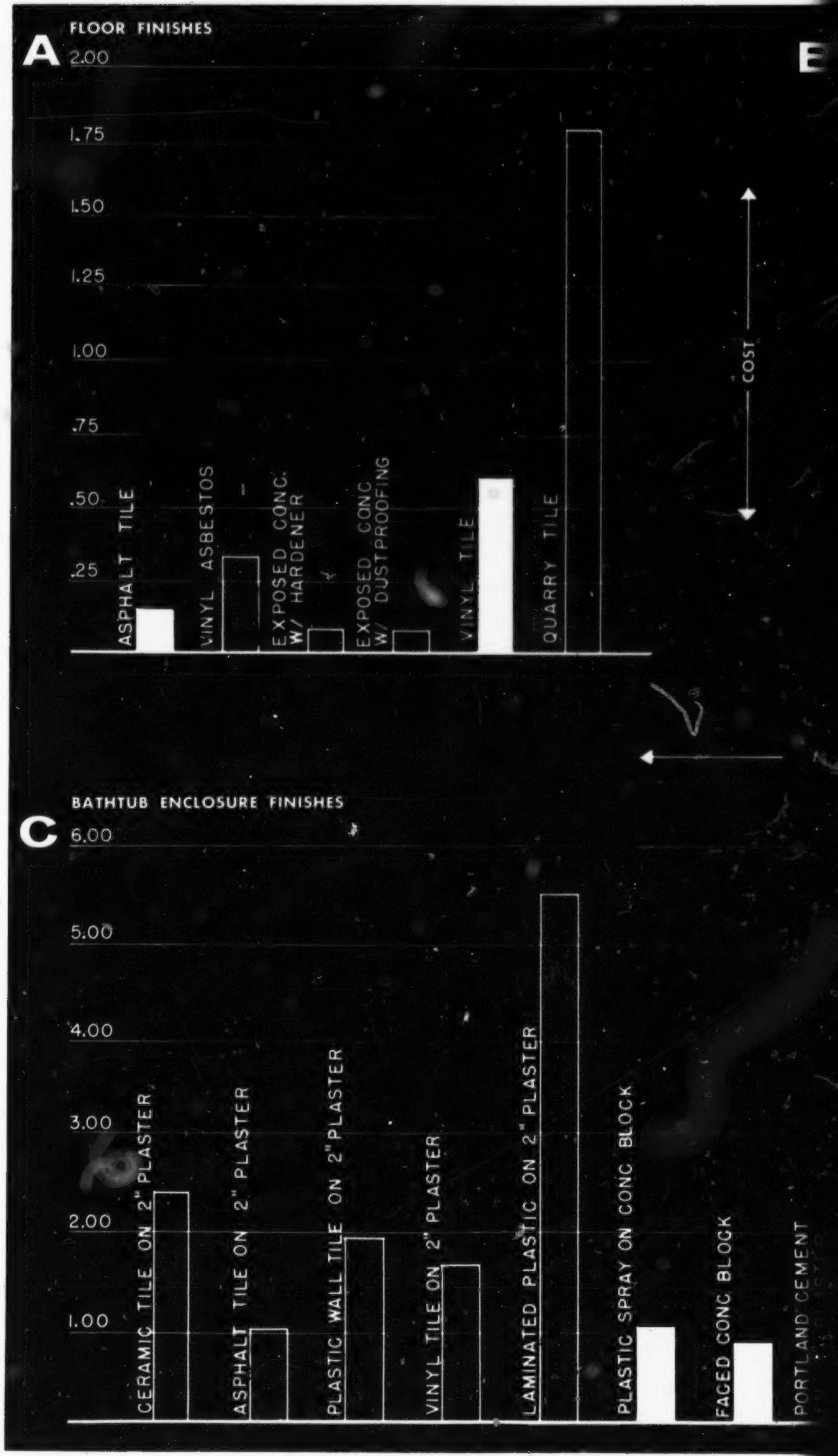
On this page will be found, in graph form, a comparative analysis of the preceding pages. The purpose is to give the reader a comparative cost picture at a quick glance. Although recommended finishes are designated, it should always be remembered that certain criteria govern the selection of a suitable material for each specific design problem. At times economy alone is the governing factor, while in other instances it is maintenance.

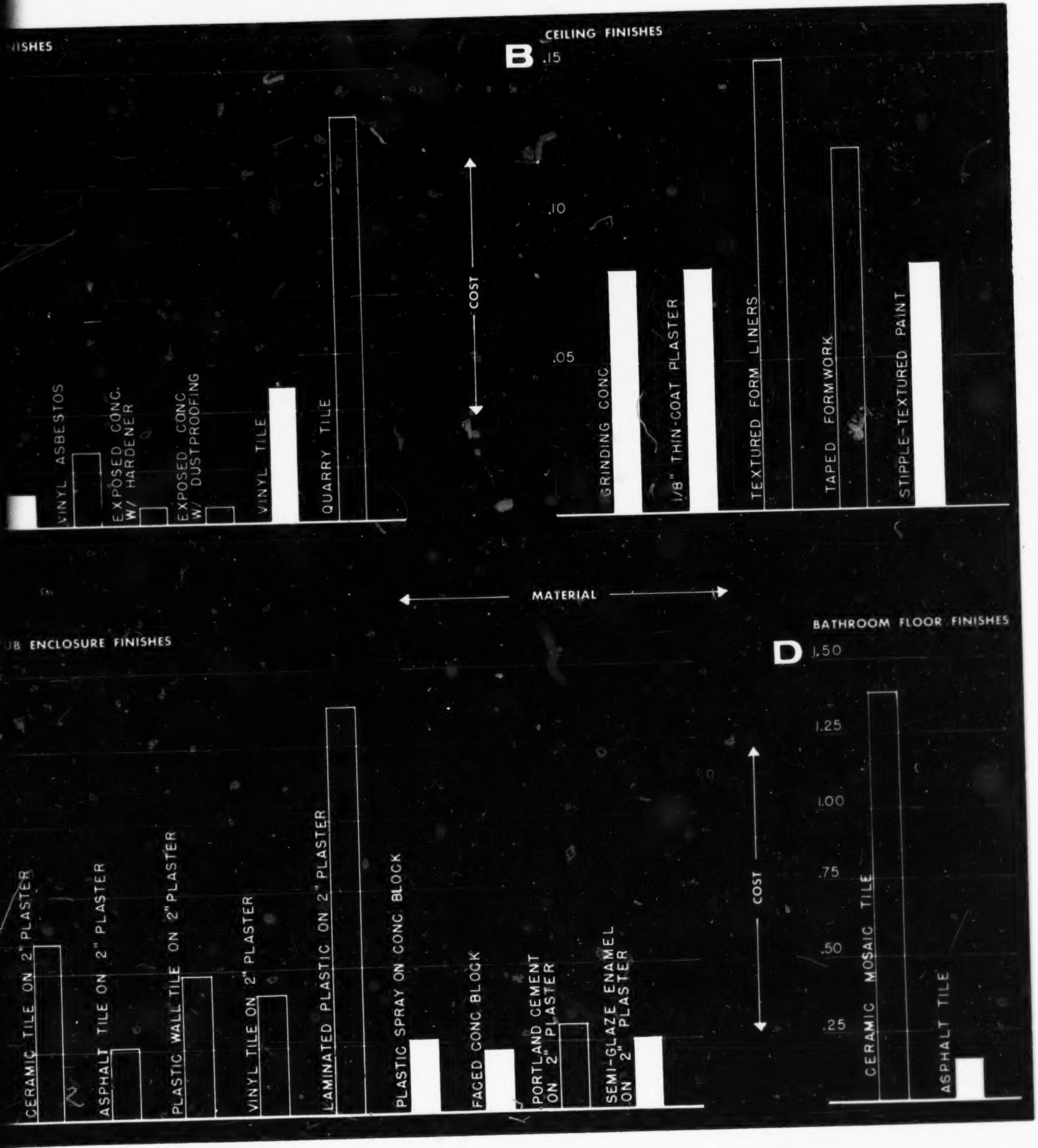
The primary purpose of this section is to show that there are alternate methods of finishing ceilings, floors, and bathrooms other than those adhered to by the Division of Housing, that will result in reasonable economies.

Listed below are the approximate square foot requirements for the existing project previously mentioned:

1. Ceiling area:
   Approximately 1,300,000 sq. ft.
2. Floor area (excluding elevator lobbies and bathrooms):
   Approximately 1,000,000 sq. ft.
3. Elevator lobby floor area:
   Approximately 30,000 sq. ft.
4. Bathroom floor area:
   Approximately 32,000 sq. ft.
5. Bathroom walls (tub enclosures):
   Approximately 16,000 sq. ft.

By using these figures and the costs shown on the graphs, an overall cost saving may be readily arrived at. An example would be to take the cost differential between ceramic mosaic floor tile and asphalt floor tile ($1.40 − .14 = $1.26) and multiply by the square footage (32,000 sq. ft.) and arrive at a project cost savings ($40,320) for this item. Note that graph columns in white denote materials recommended for their economy.




NISHES
VINYL ASBESTOS
EXPOSED CONC. W/ HARDENER
EXPOSED CONC. W/ DUSTPROOFING
VINYL TILE
QUARRY TILE
B
CEILING FINISHES
.15
.10
.05
COST
GRINDING CONC.
1/8" THIN-COAT PLASTER
TEXTURED FORM LINERS
TAPED FORMWORK
STIPPLE-TEXTURED PAINT
MATERIAL
UB ENCLOSURE FINISHES
CERAMIC TILE ON 2" PLASTER
ASPHALT TILE ON 2" PLASTER
PLASTIC WALL TILE ON 2" PLASTER
VINYL TILE ON 2" PLASTER
LAMINATED PLASTIC ON 2" PLASTER
PLASTIC SPRAY ON CONC. BLOCK
FACED CONC. BLOCK
PORTLAND CEMENT ON 2" PLASTER
SEMI-GLAZE ENAMEL ON 2" PLASTER
D
BATHROOM FLOOR FINISHES
1.50
1.25
1.00
.75
.50
.25
COST
CERAMIC MOSAIC TILE
ASPHALT TILE

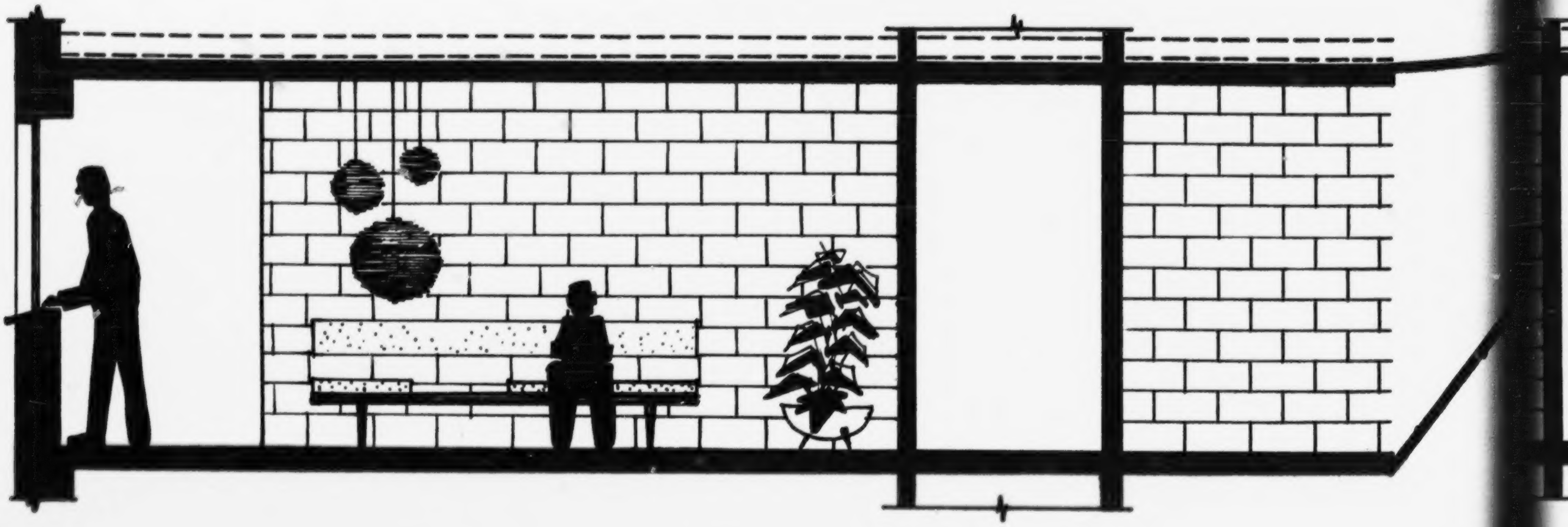
Reduction of Ceiling Height

This very controversial subject is presented in this section to show the savings possible through a code change. If the reader will approach this suggestion analytically and not interject preconceived subjective feelings, he will see that it has very definite possibilities. The criticism that the space becomes repressive is believed to be in actuality a misconception when applied to the tightly organized living and sleeping areas found in most public housing projects.

Represented across page is a suggested change in ceiling height from the current minimum height of 8'-0" to a proposed new height of 7'-6" with a resultant savings in materials and space. The first diagram shows a cross-section through a typical living room and public hall of a current New York City housing project. The length of the living room and width of the hall are the exact dimensions taken from this project. Exposed block is shown as the finish to illustrate how this material might appear in context with surrounding furniture and fixtures. The proposed 7'-6" height is drawn as the heavy black outline in the illustration, the current minimum height of 8'-0" is shown as the dotted lines above. All the furniture and fixtures are drawn to the exact scale in length and height. The standing man is drawn as 5'-9" in height. From this graphic illustration, it can easily be seen that the proposed 6" drop in standard height does little to destroy the human scale of the room. As can be seen, there is no sense of crowding or feeling of being "pinched in." It is believed that the vast majority of people, including most architects, would find it virtually impossible to perceive the change in height between 8'-0" and 7'-6" and as a result would find the enclosed volume as livable at 7'-6" as it was at the conventional 8'-0" ceiling height.

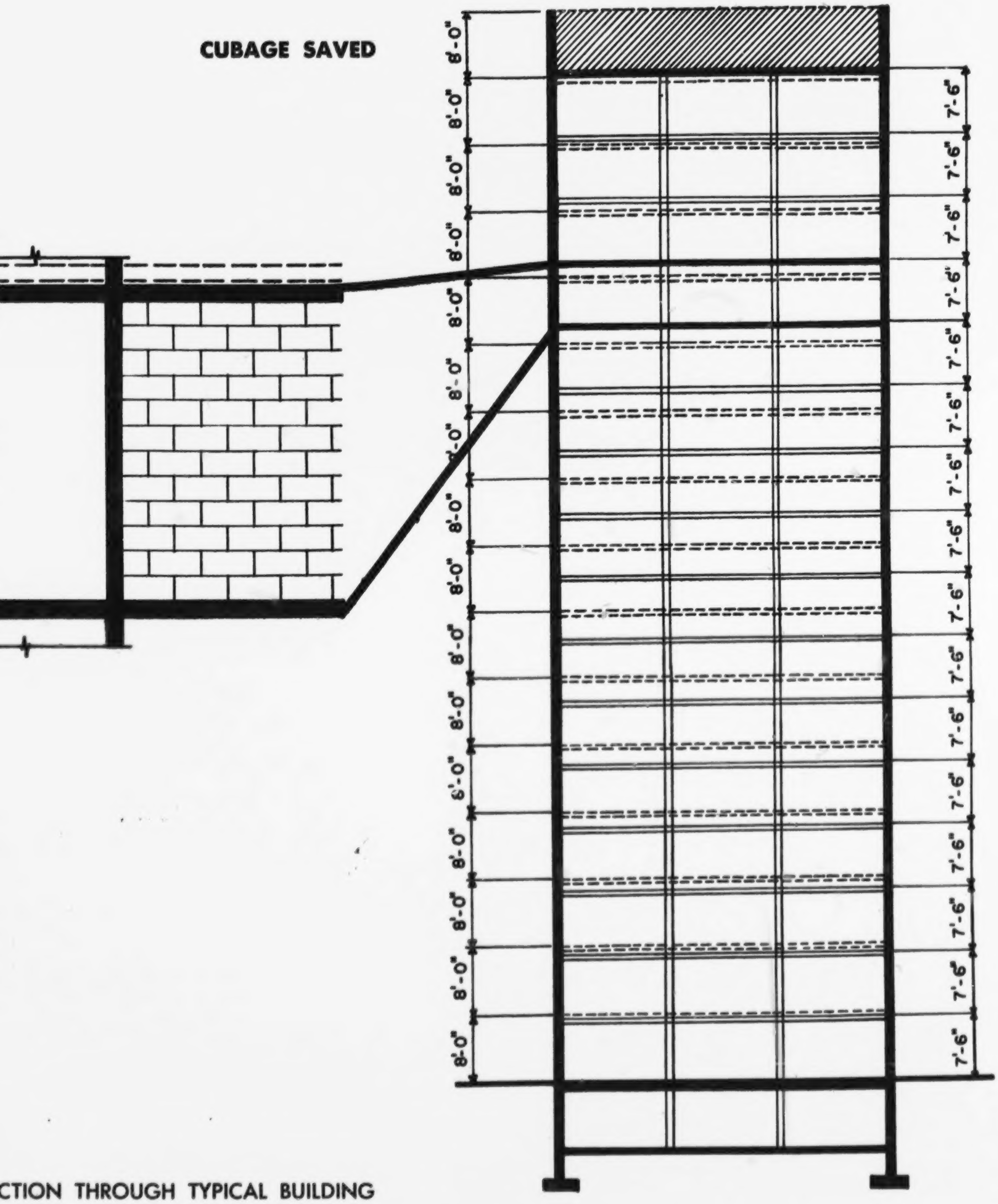
The second diagram shows a cross-section taken through a 16 story structure and illustrates the savings in volume, floor by floor, of the 7'-6" ceiling height. At the top of the structure, the overall volume is finally realized. It is one complete 8'-0" ceiling height story! Taking this one complete story height and cubing it, according to the overall dimensions of one typical wing of the current housing project used as a comparison throughout this study, there will be realized a total saving in cubage of 29,440 cu. ft.! In materials this would mean a total floor-to-ceiling height saving on all columns and reinforcing steel, one story height of 4" brick and 6" block back-up, one story height of wall plastering, one story height of interior partitions, one story height of corridor wall, one story height of all plumbing risers and stacks, one story height of electrical conduit — plus the labor cost of installing all this material. As can be easily seen, the savings involved would come out to be quite a large sum per project with no loss in livability of the project. Another saving would be realized through the resulting reduction of required heating per cubic foot of apartment.

CUBAGE SAVED



CROSS SECTION THROUGH FLOOR

SECTION THROUGH TYPICAL BUILDING


CUBAGE SAVED
8'-0"
8'-0"
8'-0"
8'-0"
8'-0"
8'-0"
8'-0"
8'-0"
8'-0"
8'-0"
8'-0"
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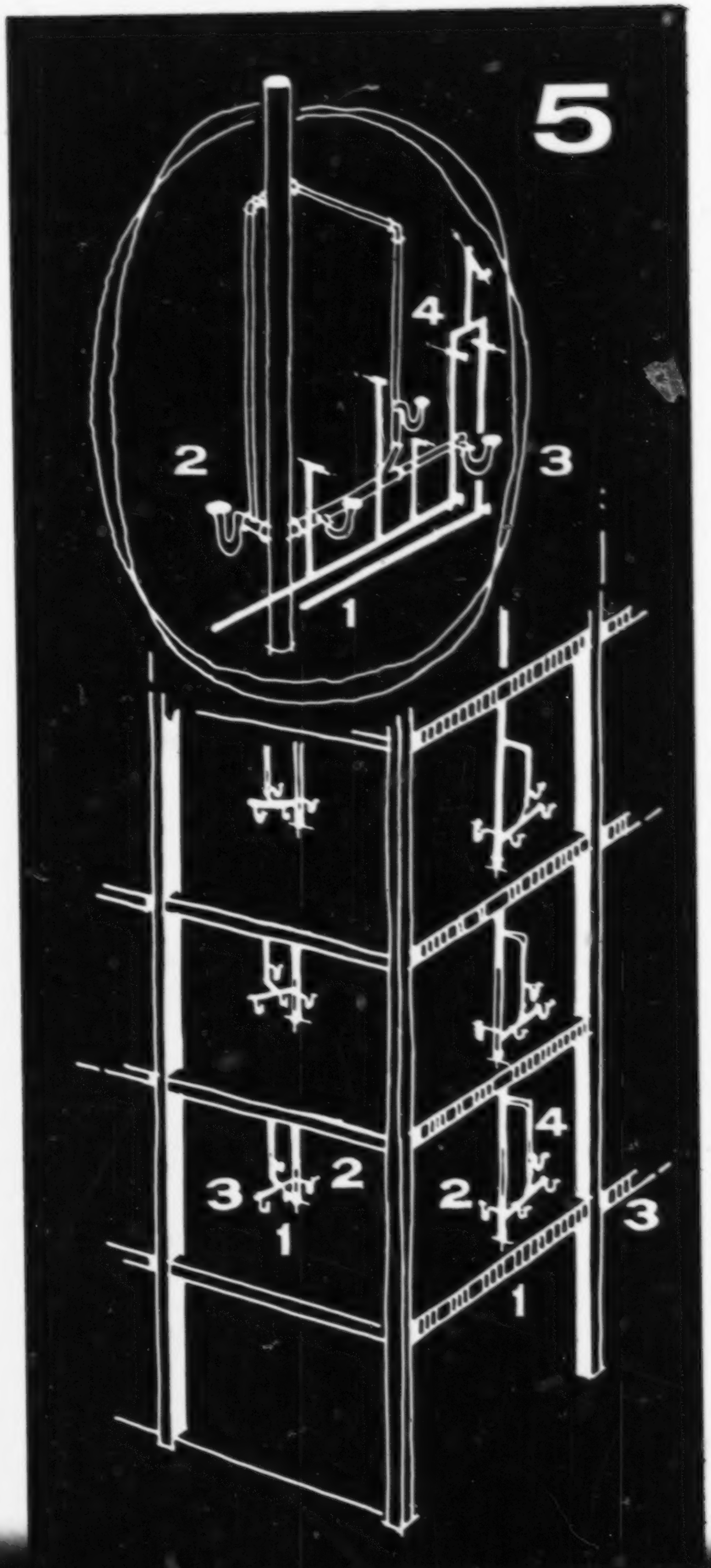
CTION THROUGH TYPICAL BUILDING

REDUCTION OF CEILING HEIGHT


5
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1
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1

CHAPTER FIVE — MECHANICAL EQUIPMENT

The possibilities for economy in the plumbing and heating systems are examined in this Chapter. The electrical work offered little opportunity for cost savings (other than the skip-stop elevators noted in Chapter One) and nothing on that subject is reported here.

Substantial economies can be echieved in plumbing, but not immediately. The most important cost savings proposals involve changes in the building code or in union regulations. The present New York City code prohibits the use of copper tubing and "loop-venting," although both are permitted by the New York State code and by most other codes. Both would permit considerable economies. Copper tubing, which is used almost everywhere in the country except New York City, actually costs more than ferrous pipe, but the saving in labor and the reduction in pipe sizes made possible by its smoothness and the fact that no allowance need be made for corrosion, results in overall economy. If copper tubing is also used for the waste and vent system, the marked reduction in the amount of space occupied by the piping is a further source of cost savings.

The present New York City code requires a separate vent for each fixture. If the much simpler "loop-vent" were permitted, it would greatly reduce the number of vent connections required, with a corresponding reduction in cost.

Prefabrication of plumbing can effect very substantial savings. Prefabrication is not forbidden by the code, but it is not looked upon with favor by the plumbers' union. However, this understandable prejudice has been overcome in other cities, and a serious effort should be made to bring about acceptance of prefabrication in New York. Prefabrication will save money regardless of the material used, but copper because of its light weight, is ideally suited for such use. Large pre-assembled sections of copper tubing can be carried by one man, whereas assemblies of cast iron pipe are difficult to handle because of their weight.

A small saving in plumbing is immediately available through the use of above-floor plumbing. Newly designed bathtubs and toilets with wall outlets, recently introduced on the market, eliminate the necessity for cutting through the floor slab, except for stacks. The fixtures are more expensive than the conventional ones, but the saving in labor more than makes up for it. Above-floor plumbing also eliminates exposed pipes on bathroom ceilings, as well as the annoying sounds that come from them.

Heating, unlike plumbing, involves no conflicts with codes or unions. But it is a field in which there is no unanimity of opinion and a scarcity of proven facts. Several alternatives to the two-pipe vacuum system now used were examined and two of them — one-pipe steam and one-pipe hot water — were selected for more thorough study, including detailed cost comparisons. The savings indicated by this study suggest that the State Division of Housing might do well to have an alternate heating design prepared for one of its current projects, so that alternate bids could be obtained. Probably the most substantial reduction in heating costs is that resulting from the insulation of the wall, as discussed in detail in Chapter Three.

1 PLUMBING

This portion of the study will examine three areas where major savings can be effected in the initial cost of the plumbing and drainage contract on housing developments. Changes in two areas would require revisions in the plumbing section of the administrative Building Code of the City of New York. Suggested changes in all three are permitted under the provisions of the New York State Construction Code:

The suggestions for changes in the three areas are:

1. A change in the material used for both water supply and drainage lines. The accepted materials for use in New York City are galvanized steel and cast iron for plumbing and drainage respectively. The first area investigated with suggested changes will be: "A Copper Plumbing System."

2. A change in the tub and water closet fixtures. The conventional tub is 5'-0" long and its waste connection runs beneath the floor. The standardly used water closet rests directly on the floor for support and has its soil connections under the floor. The second area investigated will be "Off-the-Floor Plumbing."

3. The third investigation will attempt to ascertain the cost savings inherent in adopting the state and national plumbing codes requirement for venting known as "Loop Venting."

1. "A COPPER PLUMBING SYSTEM"

Copper water tube with soldered joints has been used throughout the United States with almost complete unanimity. The only important area which does not permit its use is New York City. Copper tube has, in recent years, been widely accepted for sanitary and storm drainage lines in plumbing and drainage systems and its use is steadily increasing. It should be noted that the New York State Building Code permits the use of copper tubing for both water supply and drainage systems. The use of copper for both water supply and drainage systems, now prohibited by the Plumbing Section of the administrative code of the City of New York, would allow for substantial savings to be effected in the plumbing and drainage contract.

Copper tubing comes in nominal sizes from ¼" to 12", furnished in 20 foot lengths and in coils up to 100' long. They are available in all standard wall thicknesses — Types K, L, M, and DWV. Type K tube has the heaviest wall and is used for underground lines for all purposes. Type L tube is recognized as the standard tube for water supply and heating lines. It is lighter in weight than Type K tube, but may be used for drainage lines buried underground within the building. Type M tube, and Type DWV tube which are lighter in weight than Type L tube, are used in drainage for soil, waste and vent lines but should not be used for underground drainage lines.

The cost saving to be gained by the use of copper in plumbing and drainage systems can be divided into four general categories (none of which include the savings in maintenance costs over the years due to copper's immunity to rust, high resistance to corrosion, and greatly reduced chance of clogged lines) they are:

A — Space savings

B — Reduction in pipe sizes

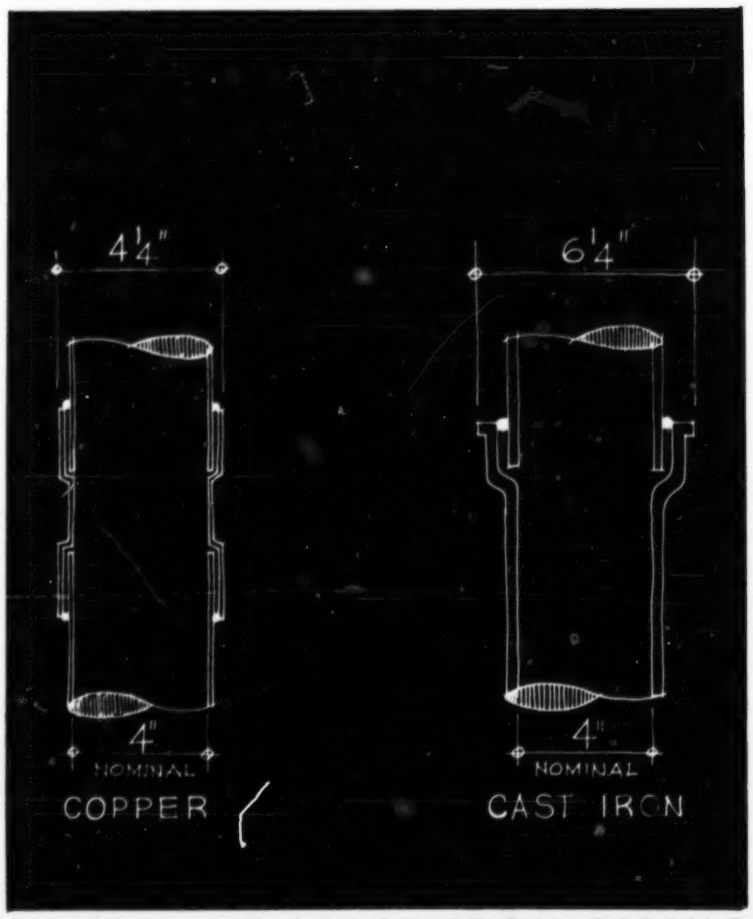
C — Economy of installation

D — Prefabrication

A SPACE SAVINGS

Whenever copper tube is substituted for cast iron drainage lines there is a savings to be effected in the construction costs, because extra wide plumbing walls are not needed. The space savings come about due to the elimination of the bell and spigot joint in favor of a soldered joint and also the thinner wall of copper tube over cast iron pipe.

The space saving which would be further increased by the reduction of copper pipe sizes, to be discussed next, amounts to approximately 1.2 square feet per plumbing wall, a substantial saving when multiplied by the total number of plumbing walls involved.



COPPER VS. CAST IRON PIPING

B REDUCTION IN PIPE SIZES

Many building codes throughout the country al
reduction in required drainage sizes when c
tube is substituted for cast iron pipe. This red
is due to the better hydraulic qualities of the s
clean inner surface of copper tube as compar
sand cast iron pipe, plus the fact that copper'
munity to rust prevents natural reduction in pipe
The smoother inside surfaces of tubes and fitting
lessen considerably the possibility of clogging
In allowing the use of soldered copper tubin
drainage lines in New York City, as suggest
realistic building code should also make some
ance for its better hydraulic qualities. A no
reduction in one pipe size is generally recommen
The cost savings in reducing all drainage line
size is obvious. A further savings in reducin
amount of space required for drainage lines,
plained previously, is also obtained.

On the basis of inside surface conditions, pipes
be classified as smooth, fairly rough and roug
follows:

Smooth: The pipe surface shows no perce
roughness. Pipes made of copper, brass, or lea
usually be classified as smooth.

Fairly rough: All ordinary pipes, such as w
iron, galvanized iron, steel and cast-iron, after
years of usage, may be called fairly rough.

Rough: Pipes that have deteriorated fairly
for some 10 or 15 years after being laid, are
fied as rough.

Pipe friction losses corresponding to these thre
of pipes for various nominal diameters for a
temperature of 50° F are shown on the fo
charts.

REDUCTION IN PIPE SIZES

ny building codes throughout the country allow a uction in required drainage sizes when copper e is substituted for cast iron pipe. This reduction lue to the better hydraulic qualities of the smooth an inner surface of copper tube as compared to d cast iron pipe, plus the fact that copper's im- nity to rust prevents natural reduction in pipe size. e smoother inside surfaces of tubes and fittings also sen considerably the possibility of clogging lines. allowing the use of soldered copper tubing for inage lines in New York City, as suggested, a listic building code should also make some allow- ce for its better hydraulic qualities. A nominal luction in one pipe size is generally recommended. e cost savings in reducing all drainage lines one e is obvious. A further savings in reducing the ount of space required for drainage lines, as ex- ined previously, is also obtained.

n the basis of inside surface conditions, pipes may classified as smooth, fairly rough and rough, as lows:

nooth: The pipe surface shows no perceptible ughness. Pipes made of copper, brass, or lead may ually be classified as smooth.

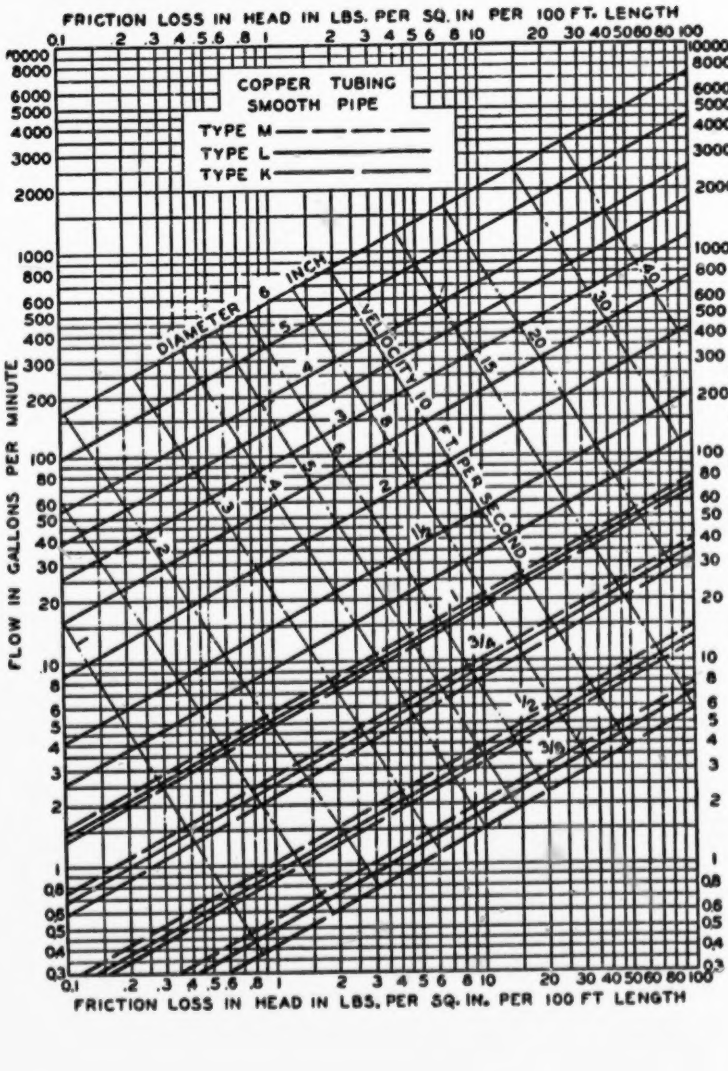
irly rough: All ordinary pipes, such as wrought on, galvanized iron, steel and cast-iron, after a few ars of usage, may be called fairly rough.

ough: Pipes that have deteriorated fairly rapidly r some 10 or 15 years after being laid, are classi- ed as rough.

pe friction losses corresponding to these three types pipes for various nominal diameters for a water mperature of 50° F are shown on the following narts.

CHART 1 SMOOTH

FLOW CHART FOR COPPER TUBING



Charts 1, 2 and 3

Reprinted from Heating Ventilating Air Conditioning Guide 1958, by permission of American Society of Heating, Refrigerating and Air-Conditioning Engineers, N.Y.C.

CHART 2 FAIRLY ROUGH

FLOW CHART FOR FAIRLY ROUGH PIPE

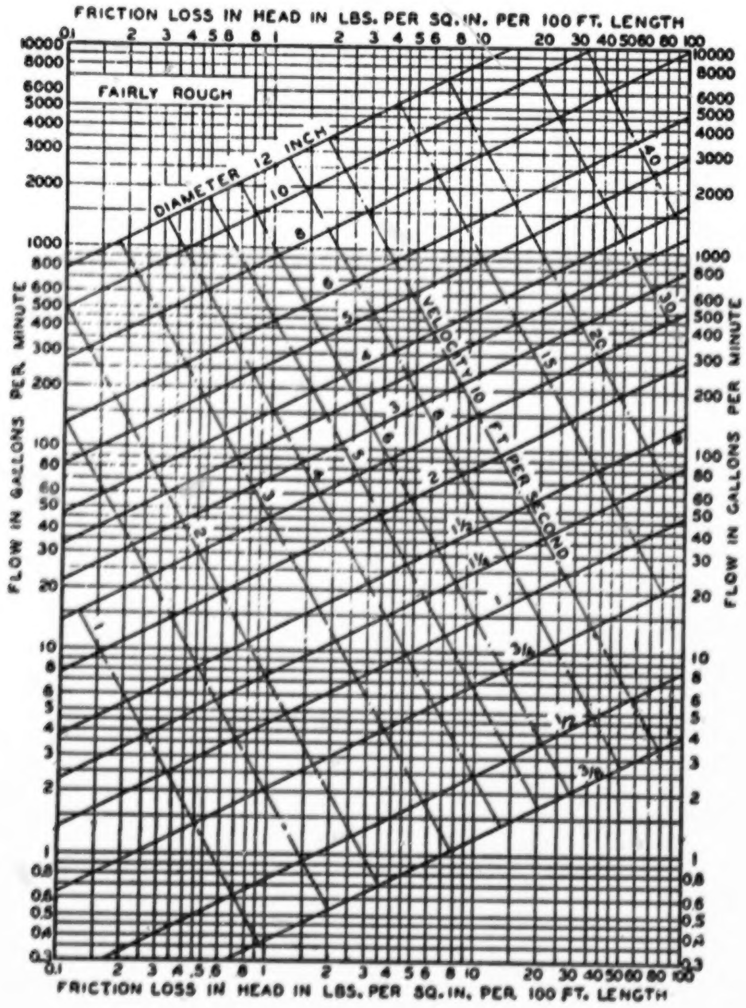
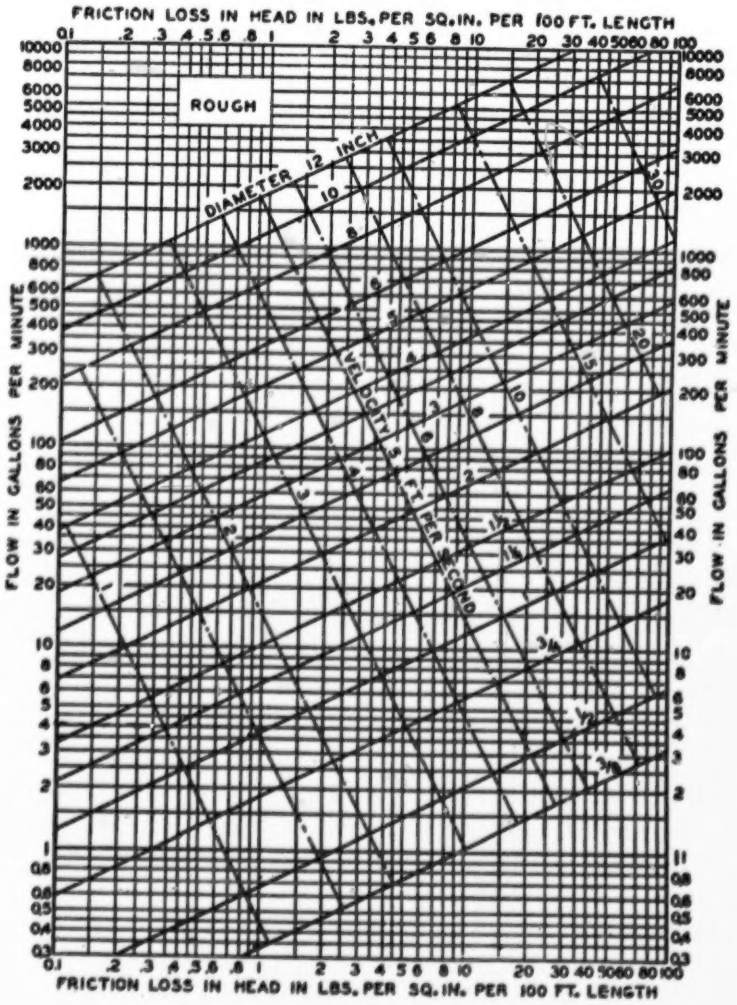


CHART 3 ROUGH

FLOW CHART FOR ROUGH PIPE



nd 3

Heating Ventilating
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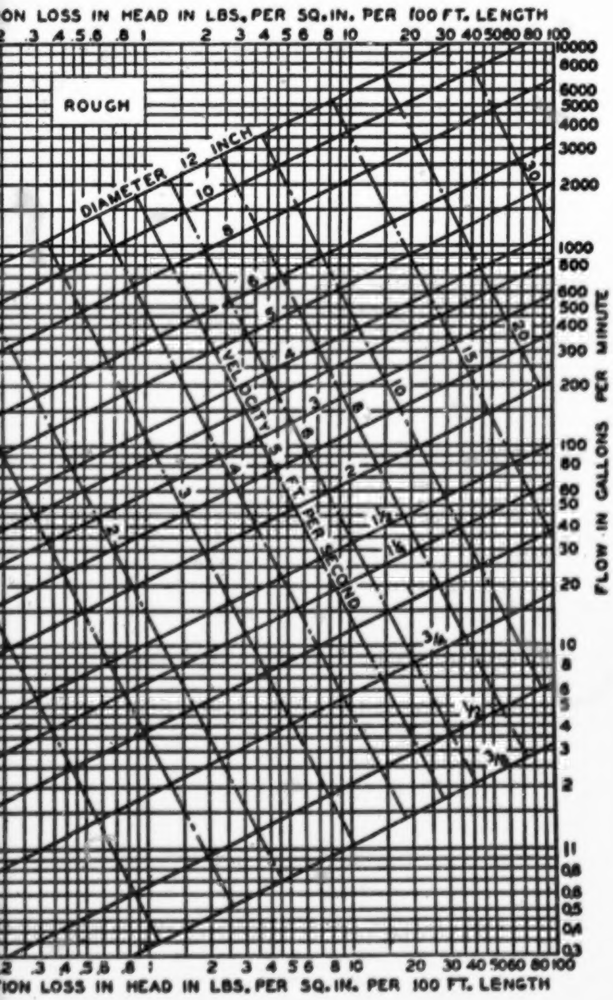
of American Society
Refrigerating and
g Engineers, N.Y.C.

3 ROUGH

CHART FOR ROUGH PIPE



C ECONOMY OF INSTALLATION

Copper tubes for drainage systems and supply systems are assembled with cast bronze solder-type fittings which come in a complete line of elbows, tees, couplings, adapters, regular and long-turn Y branches and T-Y's, traps, closet and floor flanges, etc. There is a correct fitting for every part of every job. Many plumbing contractors have found that the normal time needed for roughing-in a cast iron and steel pipe system can be reduced as much as one-half with the use of copper tube. Work can be done quickly with the light weight tools used with copper tube, eliminating the heavy equipment and extra time required for threaded pipe and caulked-and-leaded-pipe assemblies. Cutting copper tube to exact dimensions is relatively fast and easy with a hacksaw or wheel cutter, along with the fact that standard 20′ lengths eliminate many joints. Solder joints can be made easily in restricted places without worrying about wrench space, and copper tube with compact fittings give greater freedom of placement reducing cutting and patching costs.

Although copper has successfully been used on high rise apartment structures for both drainage and supply systems accurate figures on the cost savings resulting cannot be obtained. Since actual figures on copper systems in individual homes are available, these figures will be presented here, on the assumption that the cost savings to be found in an individual application can be extrapolated to a multiple application. It must be noted that for high rise structures where fixture unit loads on the drainage system attain high magnitudes, large size bronze fittings may not be available at this time, but these fittings will undoubtably become plentiful with demand. The savings due to the use of copper in the estimates based on single units would in all probability be higher for a multi-story building. These savings would run approximately 10% of the total roughing cost.

A comparative cost of copper vs. cast iron and steel plumbing and drainage installation is itemized below. These estimates were made for a 7-room, 1½ bath, ranch-type house, and under actual field conditions with these results:

HOT AND COLD WATER LINES USING GALVANIZED STEEL PIPE

14′	¾″	Galv. pipe	$ 2.38
220′	½″	Galv. pipe	28.64
32	½″	Galv. ells	5.37
6	½ x ⅜″	Galv. ells	1.66
1	¾″	Galv. ells	.21
5	½″	Galv. ells 45°	.91
14	½″	Galv. tees	3.26
1	¾ x ½″	Galv. tees	.51
1	¾ x ½ x ½″	Galv. tees	.51
27	½″	Galv. nipples	2.49
1	¾″	Galv. nipples	.12
3	½″	Galv. unions	1.61
		Misc.	1.00
		Hangers	1.00
			49.67
Labor 16 hours @ $5.55/hour			88.80
			$138.47

HOT AND COLD WATER LINES USING COPPER WATER TUBE

14′	¾″	"L"CWT	$ 4.96
220′	½″	"L"CWT	54.21
2	¾″	Adapters	.36
6	½″	Adapters	.60
6	½ x ⅜″	Ells	.96
6	½″	Ells	.96
26	½″	Ells	2.14
1	¾″	Ells	.17
5	½″	Ells	.50
14	½″	Tees	1.68
1	¾ x ½″	Tees	.26
1	¾ x ½ x ½″	Tees	.26
3	½″	Unions	.90
		Hangers	1.00
		Misc.	3.00
			71.96
Labor 10 hours @ $5.55/hour			55.50
			$127.46

DRAINAGE LINES USING CAST IRON PIPE

92′	4″	H.C.I. pipe	$110.40
3	4″	¼ bends	5.01
1	4″	DBL T-Y	8.27
1	4″	T-Y	2.00
3	4 x 2″	Tap tees	6.36
4	4 x 1½″	Tap tees	8.48
1	4 x 1¼″	Tap tees	2.12
1	4″	C.O.	1.57
2	1½″	Blk. plugs	.34
2	4″	Roof flanges	6.00
105	lbs.	Lead	22.05
11	lbs.	Oakum	4.29
5′	1¼″	Galv. W.I. pipe	2.86
25′	1½″	Galv. W.I. pipe	16.77
4′	2″	Galv. W.I. pipe	3.81
1	1¼″	DR. ell	.51
2	1½″	DR. ell	1.54
1	2″	Stringer cplg.	1.65
1	1¼″	DR. 45° ell	.51
3	1½″	DR. 45° ell	2.21
1	1¼″	DR. tee	.83
2	1½″	DR. tee	2.20
1	2″	DR. tee	1.82
1	2 x 2 x 1½ x 1½″	Cross	2.70
2	1¼″	Slip & caulk	1.92
2	1¼″	Galv. nipples	.44
6	1½″	Galv. nipples	1.58
1	2″	Galv. nipples	.34
1	2 x 1¼″	Bushing	.46
1	1¼″	Galv. plug	.22
1	1½″	Galv. plug	.29
1	2″	Galv. plug	.42
36′	1½″	Galv. stl. pipe	13.72
2′	2″	Galv. stl. pipe	1.04
6	1½″	Galv. ells	5.06
3	1½″	Galv. nipples	.79
1	2 x 1½″	Galv. coupling	.96
1	2″	Roof flange	2.50
			$244.04
Labor 43 hours @ $5.55/hour			238.65
			$482.69

Note: 3″ soil used as recommended previously

INAGE LINES
G CAST IRON PIPE

4"	H.C.I. pipe	$110.40
4"	¼ bends	5.01
4"	DBL T-Y	8.27
4"	T-Y	2.00
4x2"	Tap tees	6.36
4x1½"	Tap tees	8.48
4x1¼"	Tap tees	2.12
4"	C.O.	1.57
1½"	Blk. plugs	.34
4"	Roof flanges	6.00
lbs.	Lead	22.05
lbs.	Oakum	4.29
1¼"	Galv. W.I. pipe	2.86
1½"	Galv. W.I. pipe	16.77
2"	Galv. W.I. pipe	3.81
1¼"	DR. ell	.51
1½"	DR. ell	1.54
2"	Stringer cplg.	1.65
1¼"	DR. 45° ell	.51
1½"	DR. 45° ell	2.21
1¼"	DR. tee	.83
1½"	DR. tee	2.20
2"	DR. tee	1.82
2x2x1½x1½"	Cross	2.70
1¼"	Slip & caulk	1.92
1¼"	Galv. nipples	.44
1½"	Galv. nipples	1.58
2"	Galv. nipples	.34
2x1¼"	Bushing	.46
1¼"	Galv. plug	.22
1½"	Galv. plug	.29
2"	Galv. plug	.42
1½"	Galv. stl. pipe	13.72
2"	Galv. stl. pipe	1.04
1½"	Galv. ells	5.06
1½"	Galv. nipples	.79
2x1½"	Galv. coupling	.96
2"	Roof flange	2.50
		$244.04
r 43 hours @ $5.55/hour		238.65
		$482.69

: 3" soil used as recommended previously

DRAINAGE LINES
USING COPPER (DWV) DRAINAGE TUBE

6'	1¼"	DWV	$ 2.98
53'	1½"	DWV	31.87
11'	2"	DWV	9.02
88'	3"	DWV	127.66
2	1¼"	Ells	.90
2	2x1¼"	Ells	2.00
8	1½"	Ells	4.00
1	3x1½"	H-O ell	4.10
1	3x2"	S.O ell	4.10
1	3"	DBL ell	5.90
1	1¼"	45° ell	.40
1	1½"	45° ell	.40
1	2x1½x2"	T-Y	1.85
1	2x2x1½x1½"	DBL T-Y	3.30
3	2"	T-Y	5.55
1	3x1¼"	T-Y	2.50
2	3x1½"	T-Y	5.00
1	3x1½"	Y	4.00
1	2x1½"	T-Y	3.30
1	1½"	T-Y	1.10
2	1¼"	T-Y	2.70
1	1½"	T-Y	1.30
1	2x1½"	Coupling	1.35
2	1½"	BR. plugs	.64
1	1½"	Adapter	.37
2	2"	BR. plugs	.80
1	2"	Roof flange	2.50
2	3"	Roof flange	5.50
		Hangers	2.00
		Misc.	5.00
			$243.09
Labor 30 hours @ $5.55/hour			166.50
			$409.59

Hot and cold water lines:	
1. Galvanized steel	$138.47
2. Copper	$127.46
Saving	$ 11.01
Drainage lines:	
3. Cast iron	$482.69
4. Copper	$409.59
Saving	$ 73.10
Total saving:	$ 84.11=13½%

14 story - 60 apartment co-operative housing unit in Phoenix, Arizona used copper for both supply and drainage systems.

photo: Louis Checkman

20 story Statler Hilton Hotel in Dallas, Texas, used copper for both supply and drainage system.

D PREFABRICATION

In a copper tube system sub assemblies or entire plumbing walls can be prefabricated, at the job site on jigs set up in the plumbers' shanty, while waiting for construction to reach the roughing-in stage and in this manner the work is done more easily and faster. Prefabrication helps eliminate costly delays to building schedules, because it cuts the plumbers' on-the-job time in half; it eliminates time lost for not having the right material or enough material on the job when it's needed. It also reduces the amount of supervision required.

The comparatively light weight of copper tubes and fittings permits the economy of prefabricated subassemblies and complete plumbing walls, which add to the savings of labor costs on the job. Lightweight assemblies with strong solder joints, which cannot work loose in handling, average in weight only about one-fourth that of cast iron and steel and are easy to erect and support.

By incorporating prefabrication, the saving in installation costs increases appreciably, approximating 20% of the roughing cost. With prefabricated plumbing walls, the "off-the-floor" plumbing fixtures, to be discussed next, are most applicable.

Lightweight copper tubes and fittings permit use of time saving prefabrication methods. Example indicates roughing-in layout for sanitary drainage system of two-story house — two complete baths and kitchen sink. Circled areas are areas which can be preassembled. The approximate weights of these sections, using Type M copper tube, are:

Sec. 1	9½ lbs.	Sec. 2	13 lbs.
Sec. 3	9¼ lbs.	Sec. 4	39¾ lbs.

When Type DWV copper tube is used the total weight will be 10 lbs. less.

EFABRICATION

r tube system sub assemblies or entire alls can be prefabricated, at the job site ip in the plumbers' shanty, while waiting tion to reach the roughing-in stage and er the work is done more easily and faster. on helps eliminate costly delays to build- es, because it cuts the plumbers' on-the-job ; it eliminates time lost for not having the al or enough material on the job when it's also reduces the amount of supervision

atively light weight of copper tubes and mits the economy of prefabricated sub- and complete plumbing walls, which add gs of labor costs on the job. Lightweight with strong solder joints, which cannot in handling, average in weight only about that of cast iron and steel and are easy d support.

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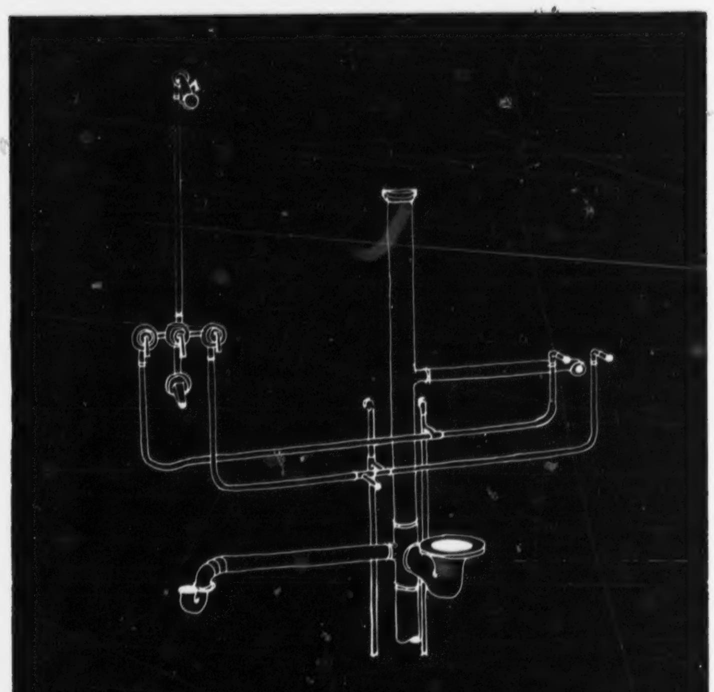
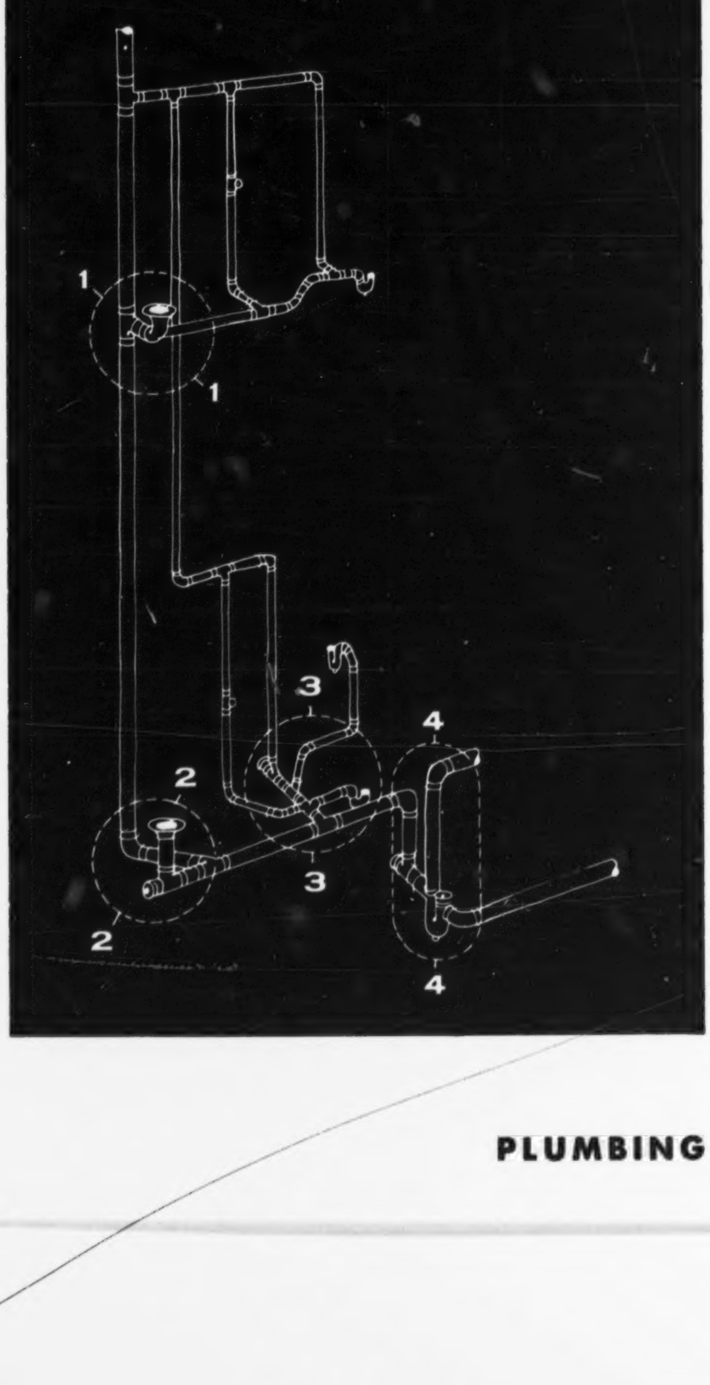

PREFABRICATED PLUMBING WALL



LIGHT WEIGHT COPPER TUBES AND FITTINGS

2. "'OFF-THE-FLOOR' PLUMBING"

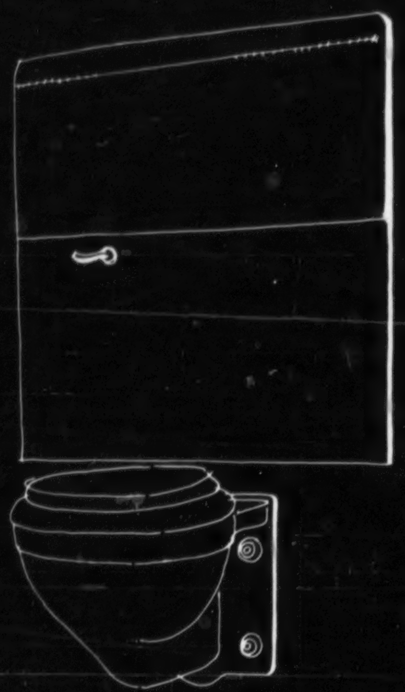
A savings in the initial cost of the plumbing and drainage contract would result if all drainage piping were kept above and free of the slab. This cost savings is brought about in the main for two reasons: a) the greater ease for plumbers to install the fixtures when all roughing connections are above the floor, b) due to the elimination of all but one sleeve through the slab. This method of "off-the-floor" plumbing is made possible by the use of two relatively recent developments in plumbing fixtures, the end outlet tub, and the wall-hung toilet.

If, in addition to the use of these fixtures, lightweight copper is used for the roughing, the savings become substantial because the labor saving qualities inherent in "off-the-floor" plumbing work hand in hand with the labor saving qualities to be found in lightweight copper.

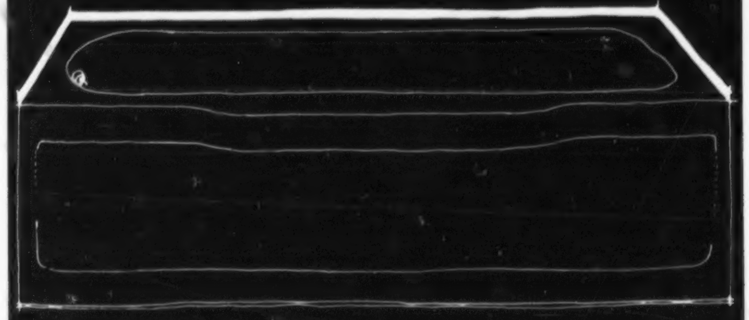
The end outlet tub, which is basically a standard tub with a raised bottom to allow the waste to run above the slab, costs exactly the same as the standard tub. (Although the fitting now costs $1.50 more than the standard fitting, it is expected that this additional cost will be eliminated in time.)

The wall-hung toilet costs approximately $50 more than the standard floor mounted toilet. But in arriving at this cost differential, it must be noted that items eliminated on the wall-hung toilet all involve labor. Therefore the gross additional cost of the wall-hung toilet, $60, less chrome plated supplies, floor flange, bowl wax, lead bend, results in a net additional cost of $50. The labor savings accrued by "off-the-floor" plumbing are due to two factors: a) The greater ease for plumbers to install fixtures to roughing. (Also note that in all the parts omitted in "off-the-floor" assembly the required labor is considerably more than the cost of parts.) Saves $25. b) The elimination of seven of the eight sleeves required in standard plumbing roughing. The savings involved here is almost entirely labor and consists of, first the design of the sleeves, then the marking and last the placing of each sheet metal sleeve. Saves $50.

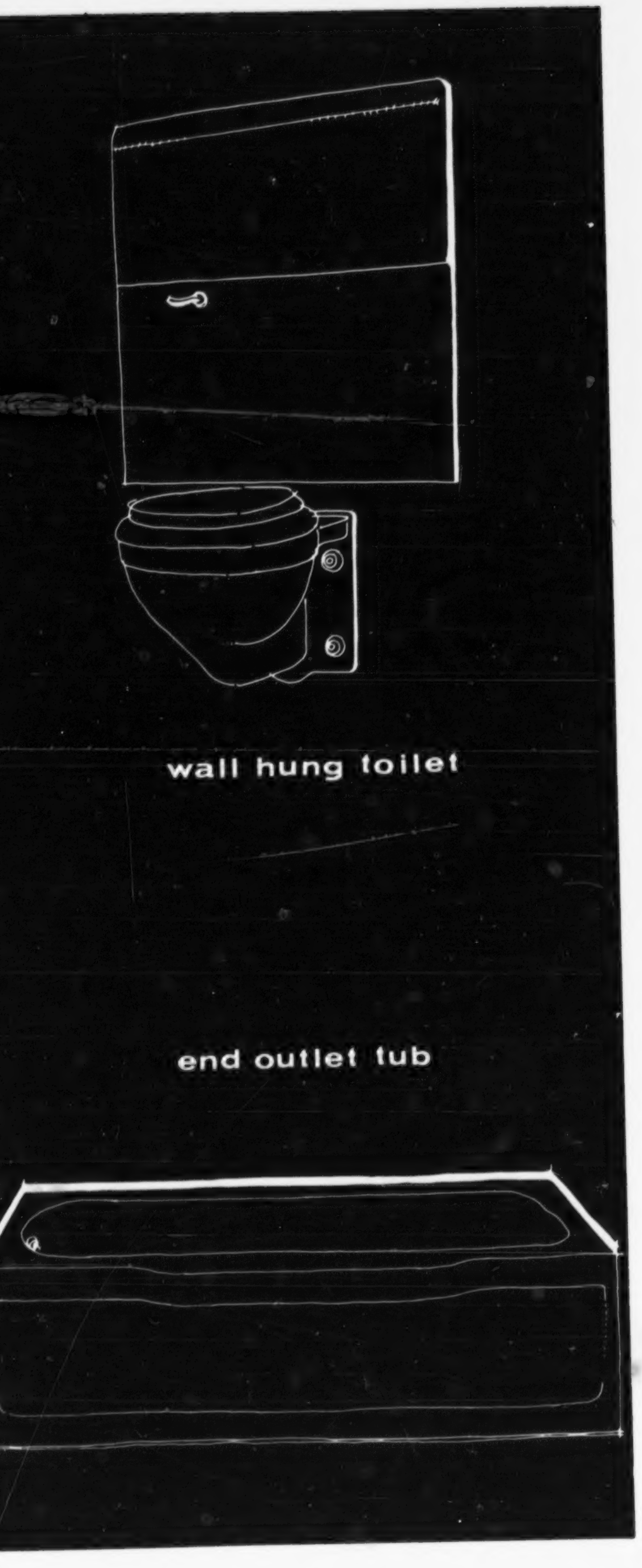
Total labor savings gained by use of these fixtures	$75
Total additional cost of "off-the-floor" fixtures	$50
Total savings	$25



wall hung toilet



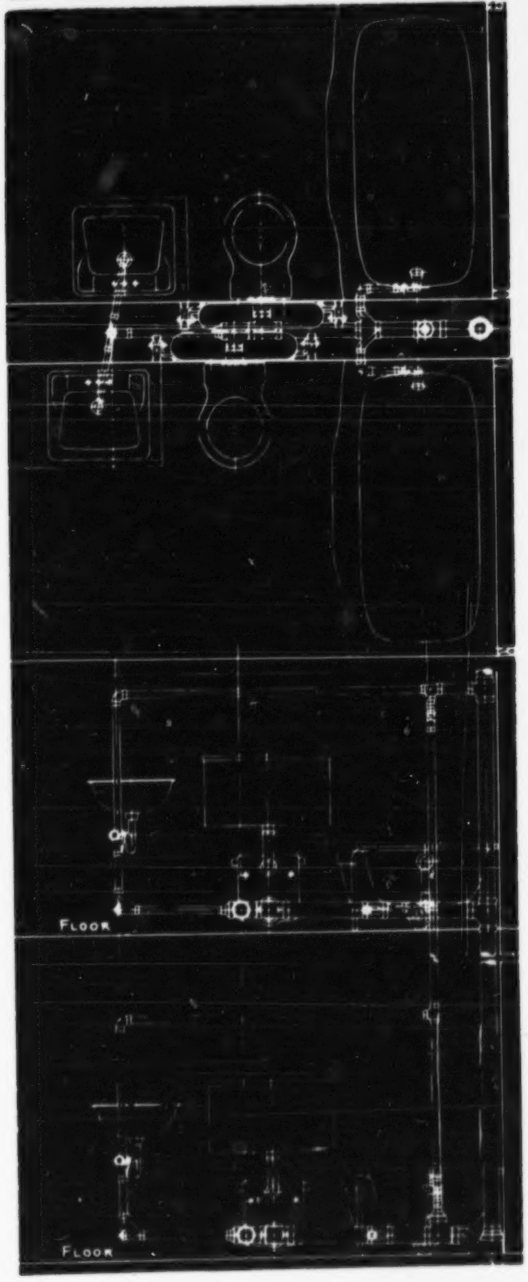
end outlet tub



There is an added labor savings in the installation of "off-the-floor" fixtures wherein no cutting and fitting of tiles is required, plus the added savings of allowing the plumbing and drainage contractor to hang the fixtures either before or after the floor is installed.

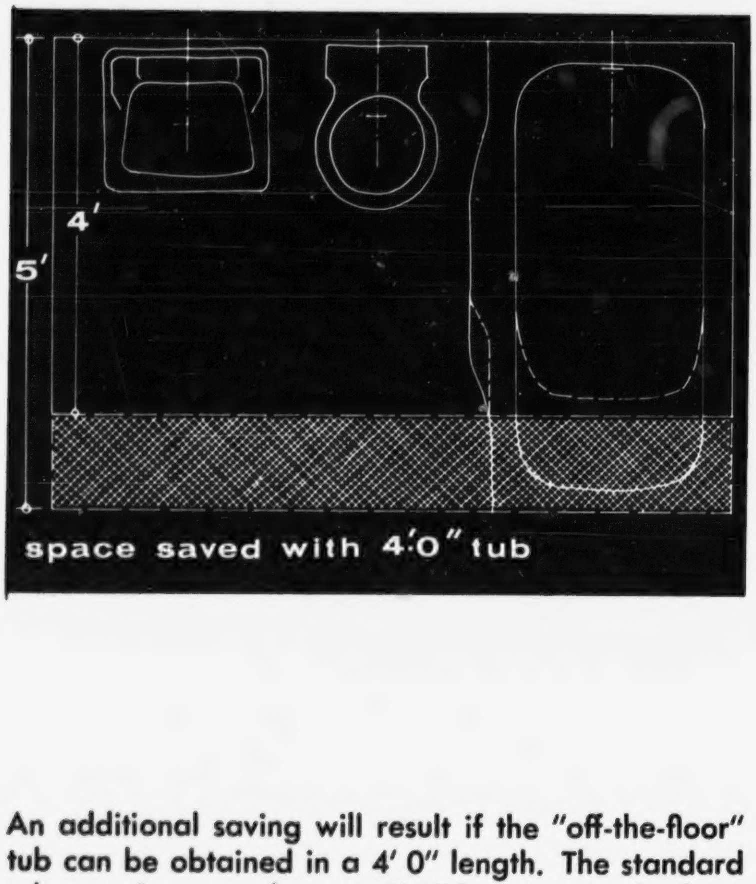
The major savings to be found in the use of "off-the-floor" fixtures is in conjunction with the use of copper plumbing. The "off-the-floor" fixtures combined with a prefabricated plumbing wall allows the plumber to install all plumbing in one trip after construction work is done.

ESTIMATED SAVINGS: $100



PLAN AND SECTION: "BACK-TO-BACK" BATHROOMS

In addition to these savings, the use of this type of fixture results in improved livability, by eliminating unsightly pipes exposed on bathroom ceiling, and annoying noises that come from them.



space saved with 4'0" tub

An additional saving will result if the "off-the-floor" tub can be obtained in a 4' 0" length. The standard tub, now in general use, is 5' 0" long. Most plumbing fixture manufacturers produce a 4' 6" long tub for today's market. This tub incorporates a straight front and a non-slope back and thus achieves a full-size bottom surface in the 4' 6" length. The 4' 0" long tub, though not in production, has proved successful in experimental models. The adoption of this length tub for use in Housing Authority buildings would save seven square feet of floor space per bath. At approximately $10 per square foot, this savings would amount to a total of $70 per bath.

3. "LOOP VENTING"

Methods of venting plumbing fixtures varies throughout the country because of the many different plumbing codes in existence. In a recent national study "loop venting" was recommended as a standard for the most efficient method of venting fixtures. The New York State Construction Code has adopted this standard, but New York City still requires individual back venting of all fixtures.

Adopting the New York State Construction Code Requirements for venting would result in the following savings:

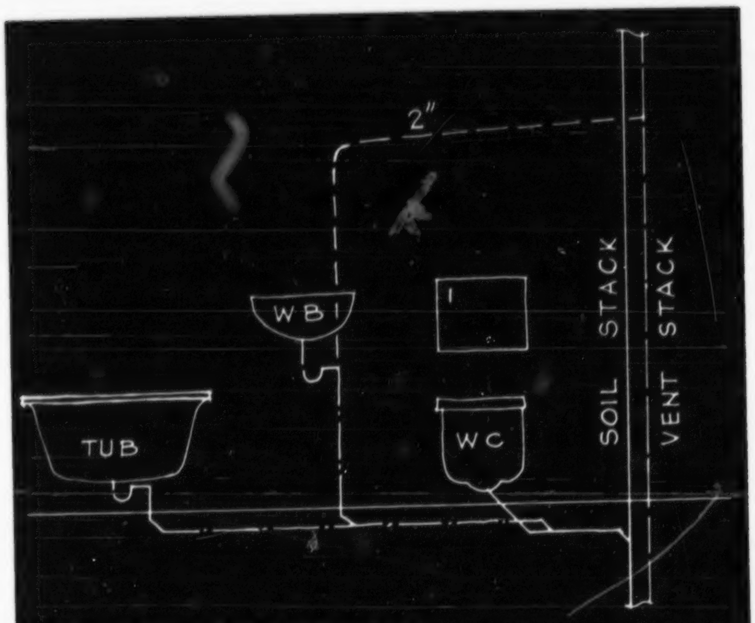
Eliminate two tees	$1.40
Change two tees to elbows	0.00
Eliminate one reducing couple	1.40
Change 2' 0" of 1½" pipe to 2" pipe	0.08
Eliminate 10' 0" of 1½" pipe	3.72
Reduce labor time 2 hours	16.00
Total savings per bath	$22.60

OP VENTING"

venting plumbing fixtures varies through-try because of the many different plumb-n existence. In a recent national study g" was recommended as a standard for cient method of venting fixtures. The New Construction Code has adopted this stand-w York City still requires individual back ll fixtures.

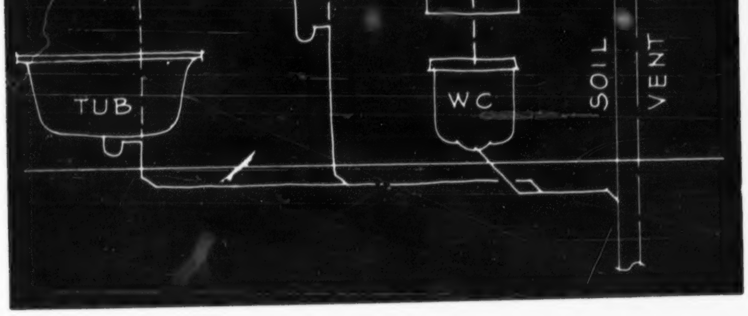
e New York State Construction Code Re-for venting would result in the following

o tees	$1.40
tees to elbows	0.00
ne reducing couple	1.40
0" of 1½" pipe to 2" pipe	0.08
0' 0" of 1½" pipe	3.72
or time 2 hours	16.00
gs per bath	$22.60


2"
WB
TUB
WC
SOIL STACK
VENT STACK

LOOP VENTING

INDIVIDUAL VENTS


1½"
1½"
2"
1½"
1½"
1½"
WB
TUB
WC
SOIL STACK
VENT STACK

2 HEATING

The heating system most commonly used for Housing Authority buildings in the New York City area is the two pipe vacuum steam heating system. A panel of sixteen heating engineers and contractors were questioned on the merits of other heating systems, as compared to the two pipe vacuum steam, for applicability in housing work along with comparative costs.

The heating systems that were compared to the two-pipe vacuum system were a one-pipe gravity return steam system, a one-pipe continuous loop steam system, a low temperature hot water system, and a high temperature hot water system.

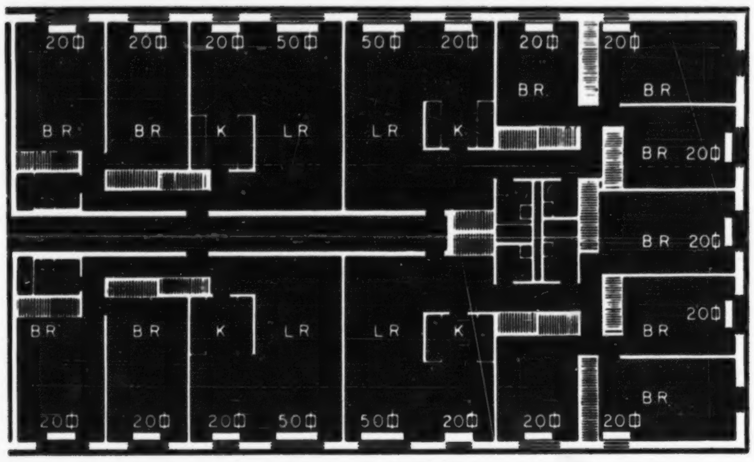
Of the sixteen experts polled, 75% considered the two pipe vacuum system to be the most suitable for Housing Authority work. Although the same percentage admitted the existence of cheaper heating systems, 67% of these felt the cheaper systems would be unacceptable for a variety of reasons and only 25% recommended using any of them.

It is the purpose of this report to select the most promising of the heating systems from the point of view of economy of installation and operation as well as from the point of view of desirability and make a detailed cost comparison with the two-pipe vacuum system to determine actual cost figures and percentage savings, if any. A plan type, selected from the structural section of this report, of a six-story building, was used for this cost comparison, because one system is limited to six stories in height, and the other can be staged in approximately six story integrals for high rise dwellings. The percentage of cost differential could then be directly related to any plan type. (The radiation figures were rounded out for convenience but remain the same for the three systems figured.)

PANEL OF CONSULTANTS

Mr. Benish	—	Syska & Hennessy, Inc.
Mr. Bodin	—	Bodin & Zinn
Mr. Davy	—	Carlson & Sweatt
Mr. Falotico	—	V. L. Falotico & Assoc.
Mr. Geelan	—	Grant T. Geelan
Mr. Goldreyer	—	Afgo Engineering Corp.
Mr. Hutton	—	Edward E. Ashley
Mr. Markush	—	E. V. Markush
Mr. Meeker	—	Meyer, Strong & Jones
Mr. Morgenstern	—	Guy B. Panero, Engineers
Mr. Mornaghine	—	Edward A. Sears
Mr. Nucktern	—	Joseph R. Loring & Assoc.
Mr. Raisler	—	Raisler Corporation
Mr. Ranger	—	Jaros, Baum & Bolles
Mr. Rosenthal	—	Lipsky & Rosenthal, Inc.
Mr. Webster	—	Guy B. Panero

Partial plan of six story building showing location and quantity of radiation. The radiation figures were rounded out for convenience, but remain the same for the three systems:


200
200
200
500
500
200
200
200
BR
BR
BR
K
LR
LR
K
BR 200
BR 200
200
BR
BR
K
LR
LR
K
BR
BR
200
200
200
500
500
200
200
200

The high temperature hot water system was judged to be undesirable by 93% of the engineers and contractors questioned. Only one felt it to be a cheaper system than the two-pipe vacuum heating system. High temperature hot water was therefore not considered for comparative study. Of those experts who found the system unacceptable, some felt it was too hazardous for housing, but most thought that it found no application in housing projects, where extensive runs are not necessary, eliminating the chief cost savings factor in the system.

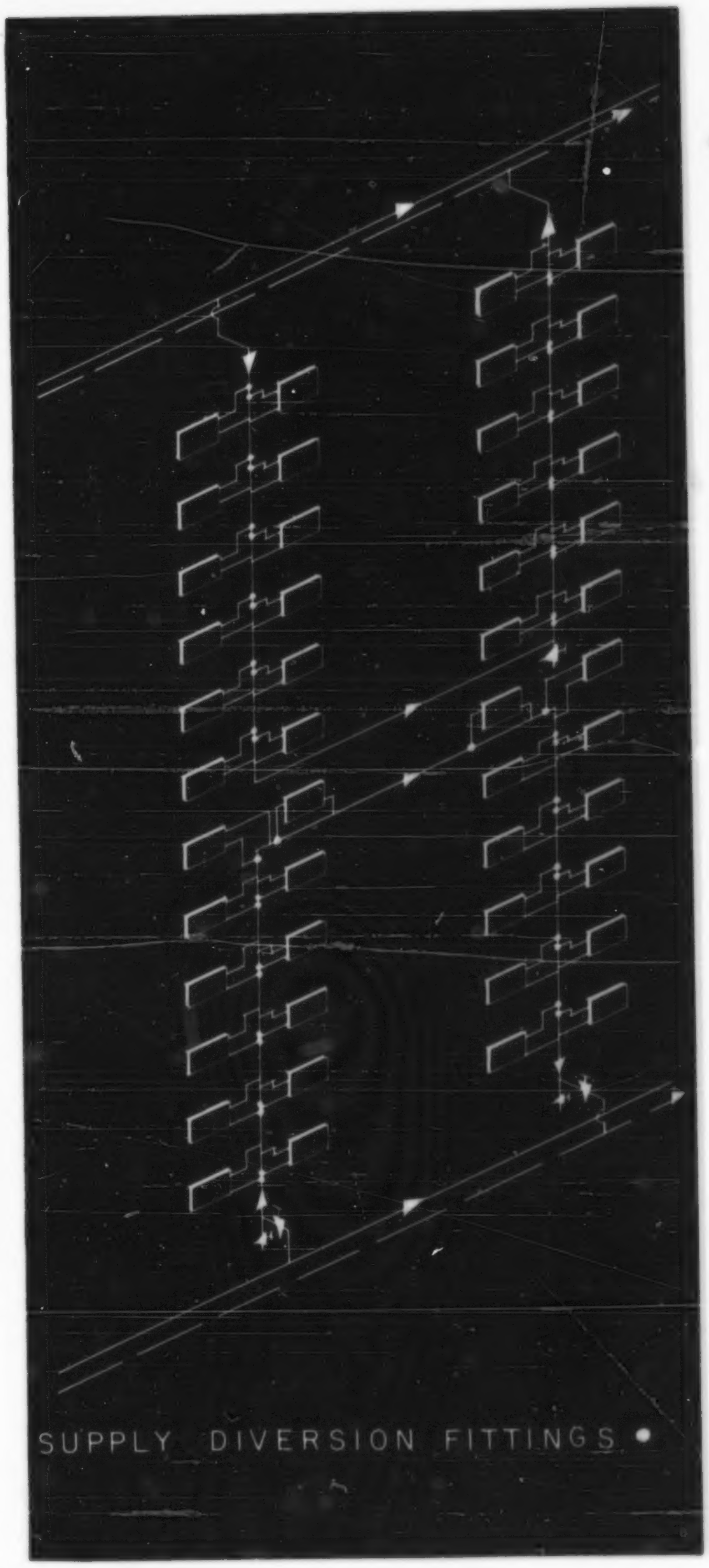
L OF CONSULTANTS

sh — Syska & Hennessy, Inc.
in — Bodin & Zinn
y — Carlson & Sweatt
tico — V. L. Falotico & Assoc.
lan — Grant T. Geelan
dreyer — Afgo Engineering Corp.
ton — Edward E. Ashley
rkush — E. V. Markush
ker — Meyer, Strong & Jones
genstern — Guy B. Panero, Engineers
naghine — Edward A. Sears
cktern — Joseph R. Loring & Assoc.
ler — Raisler Corporation
ger — Jaros, Baum & Bolles
enthal — Lipsky & Rosenthal, Inc.
ster — Guy B. Panero

The one-pipe continuous loop steam system, developed by the Metropolitan Life Insurance Company for its housing projects, is known as the "Metro System." Fifty per cent of the heating engineers and contractors on the panel found it to be undesirable for use on State Housing projects and only two panelists felt it would be less expensive to install than the conventional two-pipe vacuum steam, now in general use. This system, therefore, was not considered for comparative study. The 50% of the engineers and contractors who disapproved of the Metro System considered the lack of controls a disadvantage; felt that the effect one apartment has upon another was undesirable; and generally thought the system gave unsatisfactory results. Thirty-eight per cent of the experts indicated that the Metro System would save in maintenance costs but not in the initial cost of installation and 83% of these did not recommend its use. Of the two who felt the Metro System would save in initial costs, only one recommended its adoption. This one engineer felt that the system could be installed 10% to 15% cheaper than a two-pipe vacuum steam system, that the lack of control constituted no problem since window control is generally used regardless of the system, and that it eliminates vandalism.

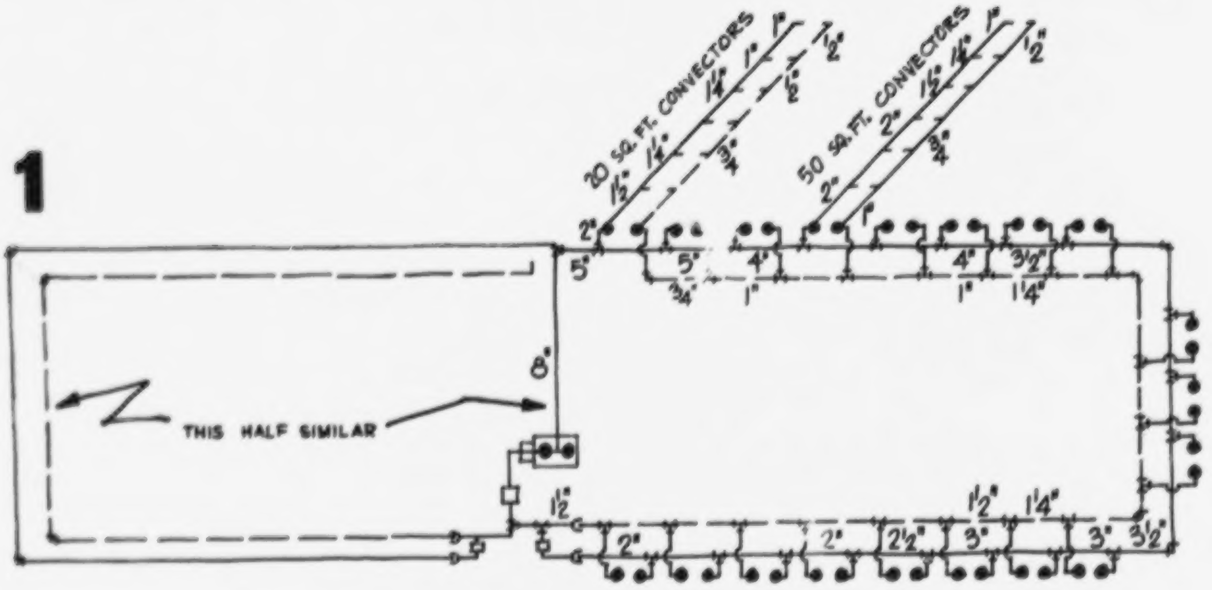
The one-pipe gravity return steam heating system is found in the majority of the privately financed multiple dwellings that have been and are being built in the New York City area. These buildings must maintain competitive standards with respect to livability and benefits given to the tenants. Since low initial cost is the prime criteria of these privately built structures, the extensive use of the one-pipe gravity steam system is indicative of the economies that may be achieved by the use of this system. It should be noted that the use to which this system has been put in private housing has been limited to six stories in height. (The height limit for the structural type used predominantly in private housing work, where land costs do not prescribe a taller building.) Of the 31% of the engineers and contractors who recommend the use of this system, all but one limited its height to six stories. The one panel member who exceeded this limit felt the system was adaptable to a fourteen story building. More than half (56%) of the experts indicated that this system would save up to 25% (an average of 19%) over an equivalent two-pipe vacuum system, but only 31% thought this system acceptable for use in Housing Authority projects. Most (69%) of the panel felt that one-pipe gravity steam system was undesirable because of poor control, poor distribution, water hammer in convectors, larger pipe sizes, troublesome air valves, higher maintenance due to steam pressure on water in lines, and higher fuel consumption (56% thought inefficient operation would eventually eliminate any savings gained in installation). Accepting the faults of the one-pipe gravity system, and acknowledging its less efficient operation, it nevertheless is the system used most frequently in private housing, built for a profit motive, where cost and maintenance are prime factors. Therefore, since most middle-income families live in buildings heated by this system, without too much discomfort, its adverse qualities are evidently not too acute. A detailed comparative study into the actual initial savings, over an equivalent two-pipe vacuum system seems called for and will be made.

A one-pipe low temperature hot water system may be staged in integrals of approximately six stories for use in high rise buildings.

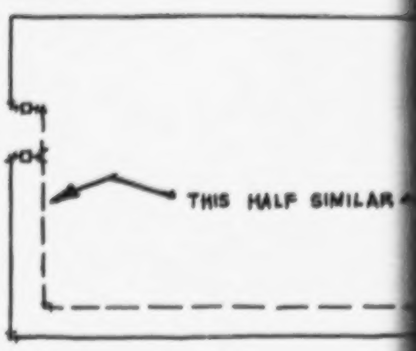


In considering a low temperature hot water heating system it was decided to analyze only the one-pipe monoflow hot water system, since it is cheaper than a two-pipe system and has the same amenities. Most (62½%) of the heating engineers and contractors recommended the use of this system, but 37½% limited its height to between two and six stories. Only 12½% felt this system would be cheaper, in initial cost, than the two-pipe vacuum system, and 31% felt it would be more expensive. The 62½% of the panel who favored the adoption of this system listed many advantages: fuel savings, reduction in maintenance, no priming of boilers, mains may run dead level providing better headroom, radiators may be placed on basement floor which cannot be done with steam, good distribution, elimination of troublesome air valves, elimination of water line difficulties (i.e. pressure differential, particularly on the larger systems with long mains), less noisy, smaller and less unsightly piping, gravity emergency heat provided by opening flow control valve (fly-wheel effect), and no overheating of living space (as with steam) since the amount of heat may be varied with weather conditions. Those not favoring a low temperature hot water system listed among their reasons a higher initial cost, larger and varying sized convectors, and the necessity to conceal all piping to eliminate the danger of water damage caused by vandalism. The height limit set by 37½% of the panel can be easily overcome by staging the system into integrals of approximately six stories, as is evidenced by the existence of a hot water system, 25-years old, in a sixty-seven story building in New York City. Considering the advantages to be gained by the use of a one-pipe low temperature hot water system it might prove fruitful to investigate the claim of 12½% of the panel members who feel this system can be installed up to 20% cheaper than an equivalent two-pipe vacuum steam system.

1


20 SQ. FT. CONVECTORS
1½"
1¼"
1¼"
1"
1"
½"
¾"
½"
50 SQ. FT. CONVECTORS
2"
1½"
1¼"
1"
2"
¾"
½"
1"
2"
5"
5"
¾"
4"
1"
4"
3½"
1"
1¼"
8"
THIS HALF SIMILAR
1½"
2"
2"
2½"
3"
3"
3½"
1½"
1¼"

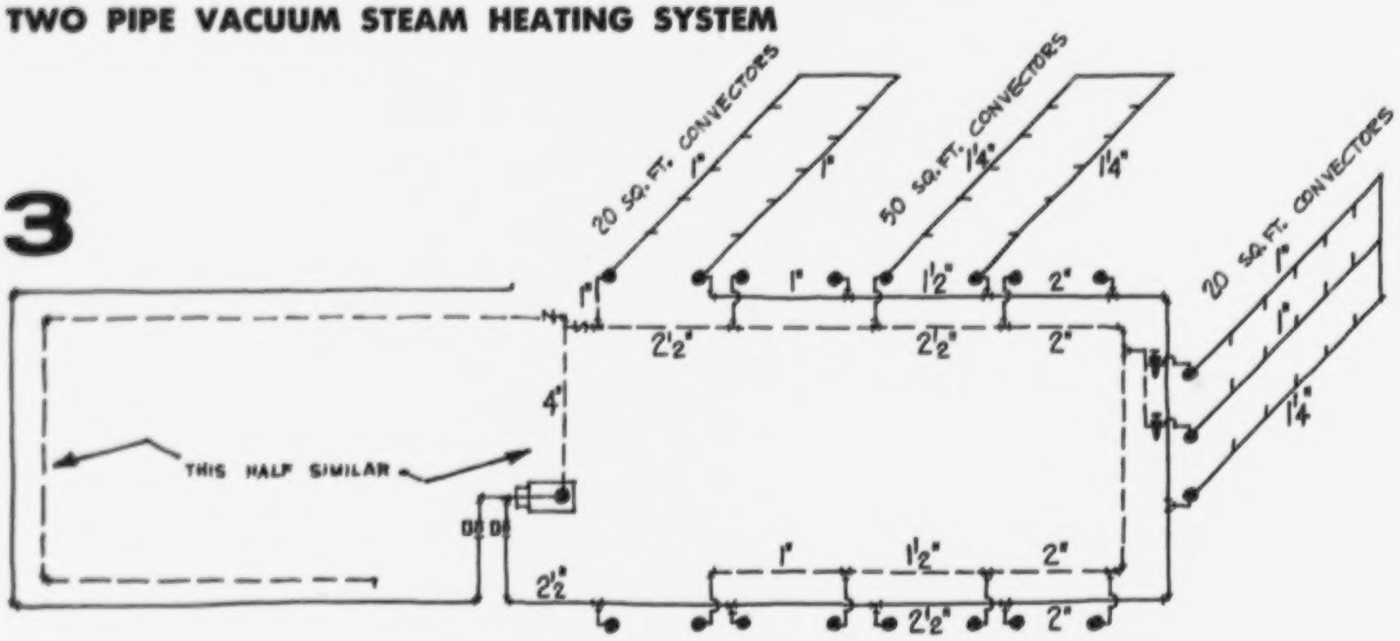
2


THIS HALF SIMILAR

DIAGRAMATIC PLAN — RISERS AND MAINS

TWO PIPE VACUUM STEAM HEATING SYSTEM

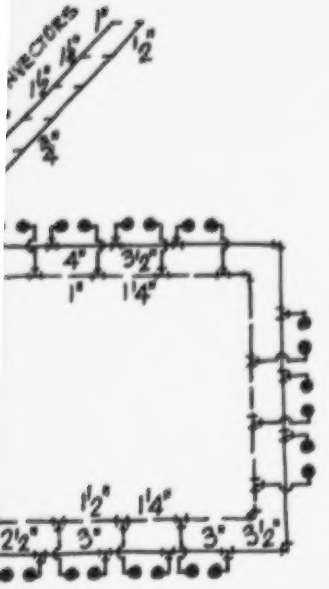
3


20 SQ. FT. CONVECTORS
1"
1"
50 SQ. FT. CONVECTORS
1¼"
1¼"
20 SQ. FT. CONVECTORS
1"
1"
1¼"
1"
1"
1½"
2"
2½"
2½"
2"
4"
THIS HALF SIMILAR
2½"
1"
1½"
2"
2½"
2"

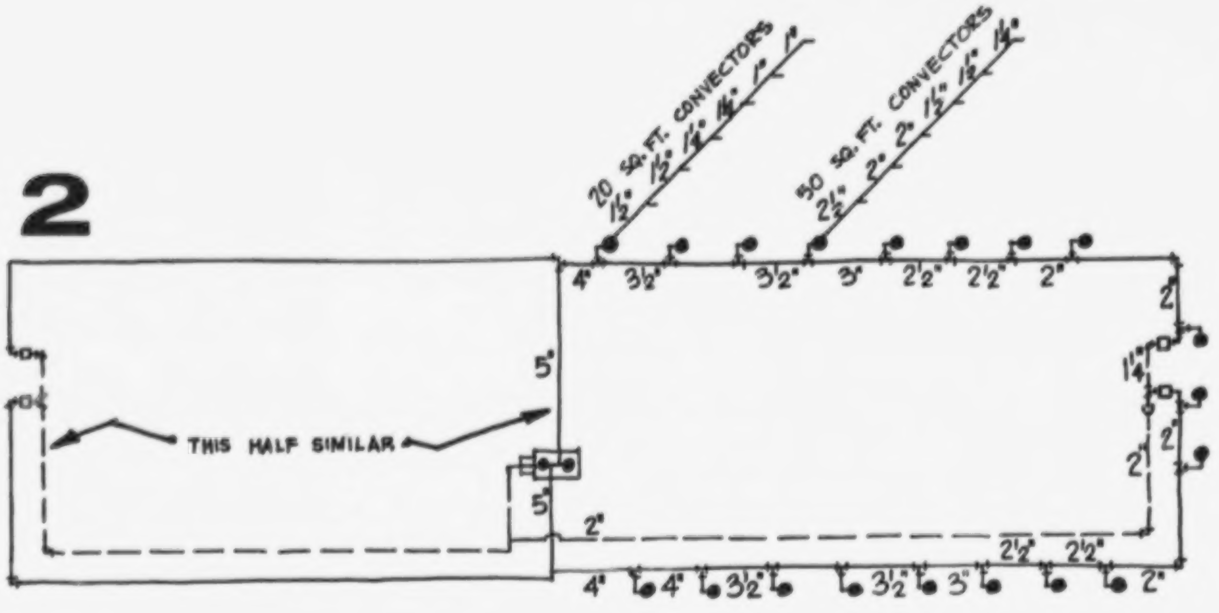
DIAGRAMATIC PLAN — RISERS AND MAINS

ONE PIPE HOT WATER HEATING SYSTEM

HEATING

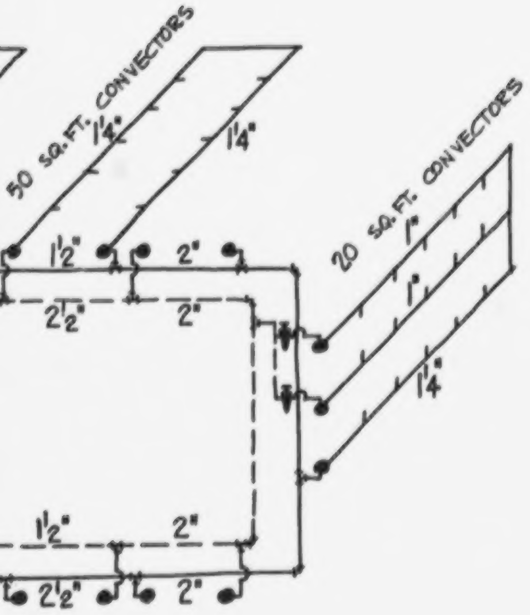

CONVECTORS
1½"
1¼"
1"
½"
¾"
4"
3½"
1"
1¼"
1½"
1¼"
2½"
3"
3"
3½"

2

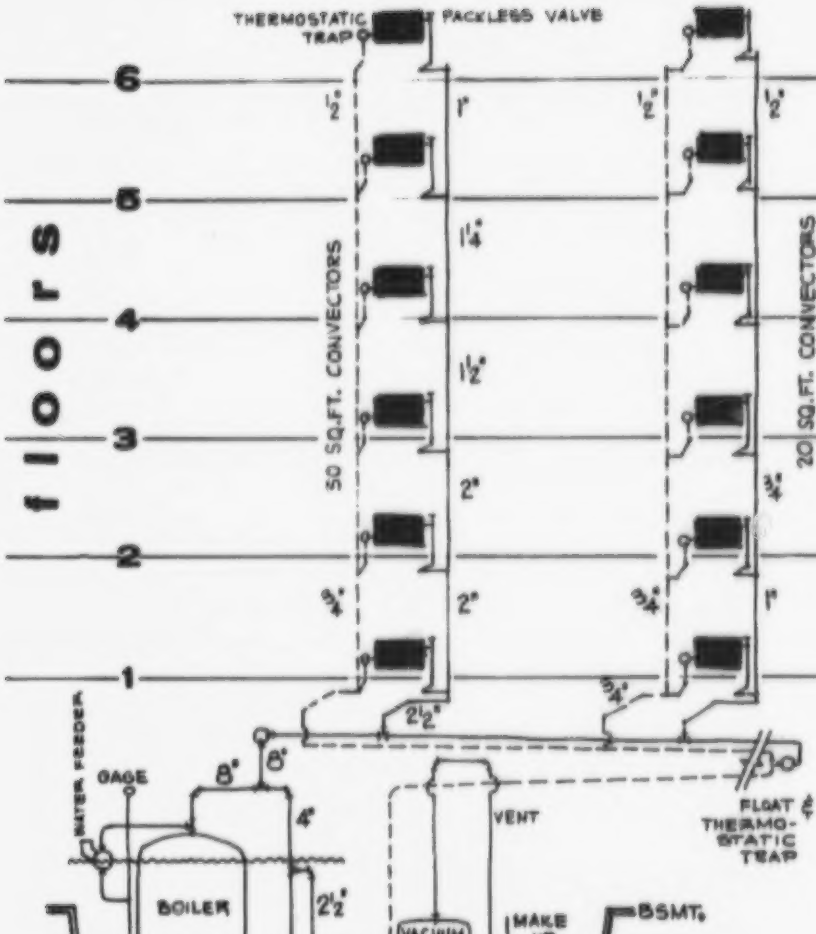

20 SQ. FT. CONVECTORS
1½"
1½"
1¼"
1¼"
1"
1"
50 SQ. FT. CONVECTORS
2½"
2"
2"
1½"
1½"
1¼"
4"
3½"
3½"
3"
2½"
2½"
2"
2"
1¼"
2"
2"
5"
5"
THIS HALF SIMILAR
2"
2½"
2½"
4"
4"
3½"
3½"
3"
2"

DIAGRAMATIC PLAN — RISERS AND MAINS

ONE PIPE GRAVITY STEAM HEATING SYSTEM


50 SQ. FT. CONVECTORS
1¼"
1¼"
1½"
2"
2½"
2"
20 SQ. FT. CONVECTORS
1"
1"
1¼"
1½"
2"
2½"
2"

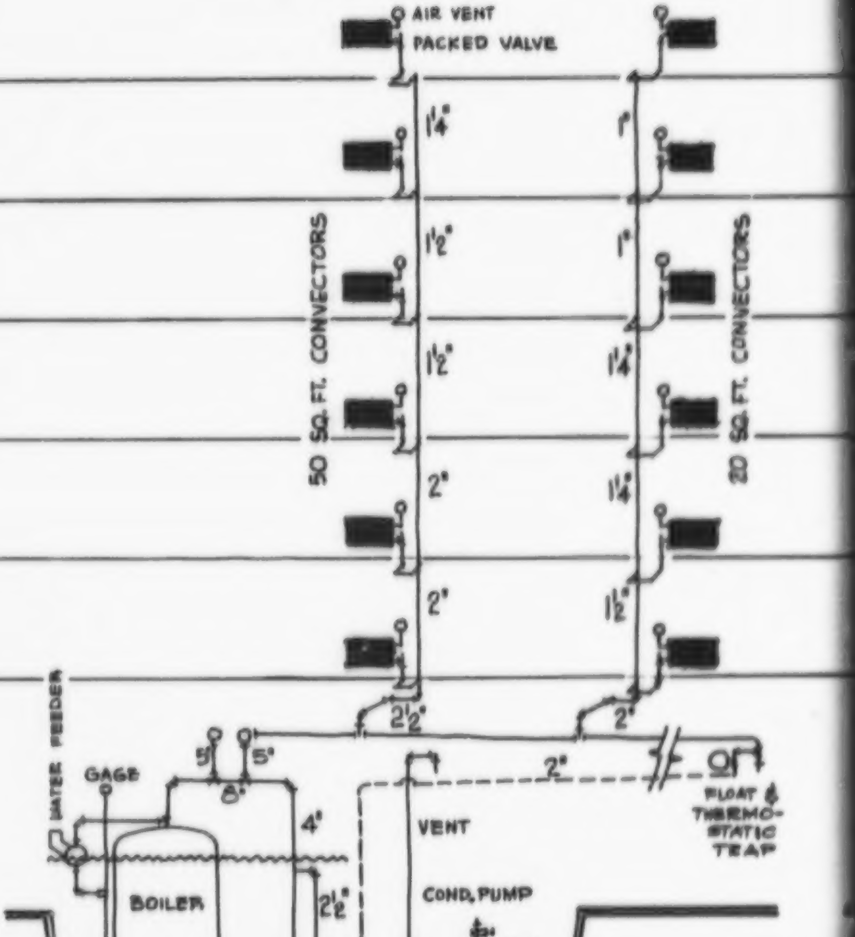
Diagramatic half plans of mains and risers for three heating systems. All risers for the 20 sq. ft. radiators and the 50 sq. ft. radiators respectively to be the same as shown on plans above. All risers for groups of 20 sq. ft. and 50 sq. ft. radiators respectively also to be the same as shown on plans. On the next page are diagramatic sections of the three plans illustrated above.


THERMOSTATIC TRAP
PACKLESS VALVE
floors
6
5
4
3
2
1
1/2"
1"
1 1/4"
1 1/2"
2"
2"
3/4"
1/2"
1/2"
3/4"
3/4"
1"
3/4"
50 SQ.FT. CONVECTORS
20 SQ.FT. CONVECTORS
2 1/2"
WATER FEEDER
GAGE
8"
8"
4"
2 1/2"
BOILER
VENT
VACUUM PUMP
MAKE UP
DR.
CK.
PIT
BSMT.
FLOAT & THERMO-STATIC TRAP

1

DIAGRAMATIC SECTION

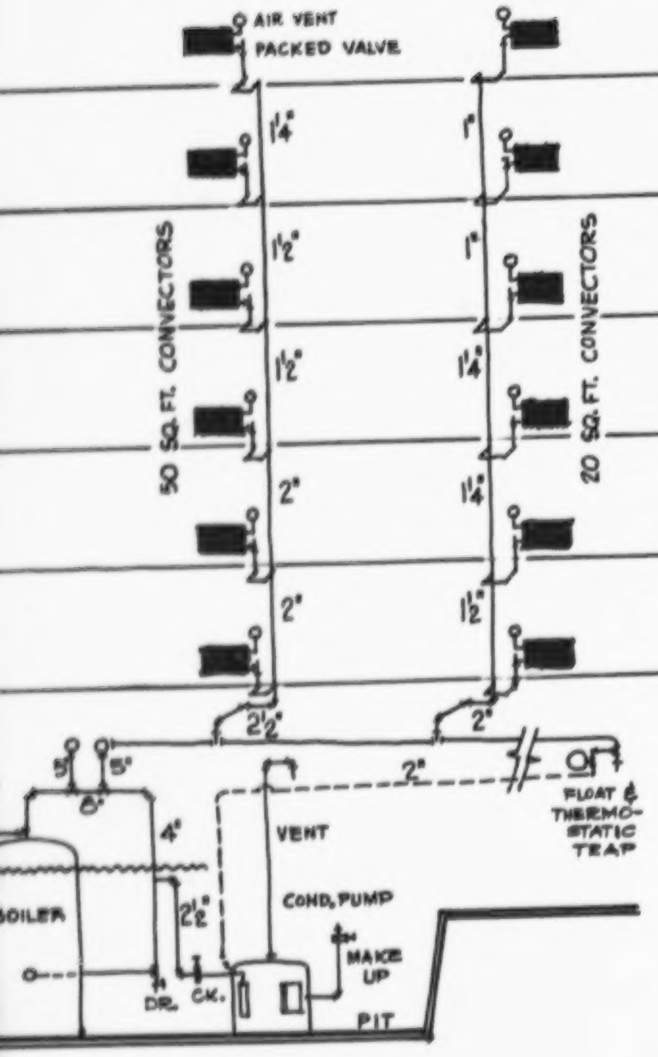
TWO PIPE VACUUM STEAM HEATING SYSTEM


AIR VENT
PACKED VALVE
1 1/4"
1 1/2"
1 1/2"
2"
2"
1"
1"
1 1/4"
1 1/4"
1 1/2"
50 SQ.FT. CONVECTORS
20 SQ.FT. CONVECTORS
2 1/2"
2"
WATER FEEDER
GAGE
5"
5"
8"
4"
2 1/2"
BOILER
VENT
COND. PUMP
MAKE UP
DR.
CK.
PIT
2"
FLOAT & THERMO-STATIC TRAP

2

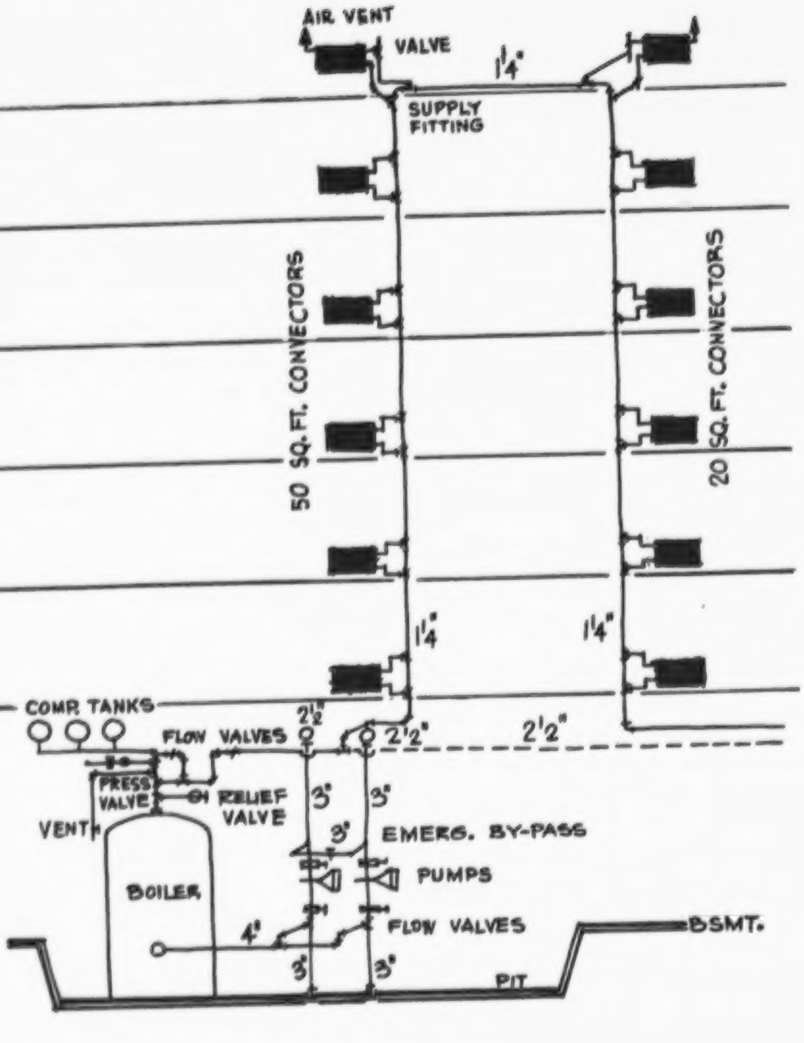
DIAGRAMATIC SECTION

ONE PIPE GRAVITY STEAM HEATING SYSTEM


AIR VENT
PACKED VALVE
1¼"
1½"
1½"
2"
2"
2½"
1"
1"
1¼"
1¼"
1½"
2"
50 SQ. FT. CONVECTORS
20 SQ. FT. CONVECTORS
5"
5"
6"
4"
2"
VENT
FLOAT & THERMO-STATIC TRAP
BOILER
2½"
COND. PUMP
MAKE UP
DR.
CK.
PIT

GRAMATIC SECTION

PIPE GRAVITY STEAM HEATING SYSTEM


AIR VENT
VALVE
1¼"
SUPPLY FITTING
50 SQ. FT. CONVECTORS
20 SQ. FT. CONVECTORS
1¼"
1¼"
COMP. TANKS
2½"
FLOW VALVES
2½"
2½"
PRESS VALVE
RELIEF VALVE
VENT
3"
3"
3"
EMERG. BY-PASS
PUMPS
BOILER
4"
FLOW VALVES
3"
3"
BSMT.
PIT

3

DIAGRAMATIC SECTION

ONE PIPE HOT WATER HEATING SYSTEM

1 TWO PIPE VACUUM STEAM SYSTEM:

RISERS & MAINS (½ BUILDING)

Pipe	30′	5″	$ 72.00
	40′	4″	62.80
	60′	3½″	99.80
	30′	2½″	30.00
	110′	2″	84.00
	130′	2″	63.79
	175′	1½″	63.83
	570′	1¼″	175.50
	420′	1″	98.02
	770′	¾″	128.07
	340′	½″	35.49
Elbows	1	3½″	$ 2.25
	1	3″	1.69
	12	2½″	13.44
	45	2″	28.80
	2	1¼″	0.62
	31	1″	6.82
	46	¾″	8.28
	15	½″	0.30
Tees			
	2	5″	$36.00
	1	5 x 4″	
	3	4″	19.08
	1	4 x 3½″	
	4	3½″	18.45
	1	3½ x 3″	
	2	3″	7.17
	1	3 x 2½″	
	1	2½ x 2″	1.58
	11	2″	13.18
	4	2 x 1½″	
	6	1½″	17.42
	20	1½ x 1¼″	
	6	1¼″	29.12
	20	1¼ x 1″	
	30	1¼ x 1¼″	
	18	1″	6.67
	5	1″ x ¾″	
	57	¾″	16.72
	19	¾ x ½″	
	19	½″	3.42
	1	F & T trap	$ 17.25
	114	Packless valves	524.40
	114	Packless traps	627.00
½ Building			2312.96
Total Building			**$4625.92**

BOILER ROOM

1 10330 EDR boiler	$2671.00
1 oil burner	4300.00
1 vacuum pump	1115.00
1 low water cut off and feed valve	63.39
2 2½″ gate valves	49.80
2 2″ gate valves	30.68
3 1″ gate valves	18.96
1 swing check	21.64
1 air eliminator	17.00
Pipe	
58′ 8″	$246.30
8′ 4″	15.00
10′ 2½″	7.60
4′ 2″	2.50
30′ 1″	7.00
Elbows	
2 8″	$ 58.42
1 8 x 4″	36.29
4 2½″	4.48
4 1½″	2.08
4 1″	0.88
Tees	
1 8″	$ 49.99
1 8 x 5″	
1 5″	13.72
1 4 x 2½″	9.54
1 4 x 4 x 1″	1.42
1 2½ x 2½ x 1″	1.16
4 1″	
Boiler room total:	**$8743.85**

MATERIAL

Mains and risers	$4625.92
Boiler room	8743.85
Convectors	5600.00
Covering	1200.00

LABOR

Mains and risers	20 days	
38 supply risers	13	
38 returns	10	
114 convectors	12	
Boiler room	15	
	70 days	- $5600.00
Total		**$25,769.77**

STEAM SYSTEM:

OILER ROOM

10330 EDR boiler	$2671.00
oil burner	4300.00
vacuum pump	1115.00
low water cut off and feed valve	63.39
2½" gate valves	49.80
2" gate valves	30.68
1" gate valves	18.96
swing check	21.64
air eliminator	17.00
ipe	
8' 8"	$246.30
8' 4"	15.00
0' 2½"	7.60
4' 2"	2.50
0' 1"	7.00
lbows	
2 8"	$ 58.42
1 8x4"	36.29
4 2½"	4.48
4 1½"	2.08
4 1"	0.88
Tees	
1 8"	$ 49.99
1 8x5"	
1 5"	13.72
1 4x2½"	9.54
1 4x4x1"	1.42
1 2½x2½x1"	1.16
4 1"	
Boiler room total:	**$8743.85**

MATERIAL

Mains and risers	$4625.92
Boiler room	8743.85
Convectors	5600.00
Covering	1200.00

LABOR

Mains and risers	20 days	
38 supply risers	13	
38 returns	10	
114 convectors	12	
Boiler room	15	
	70 days	– $5600.00
Total		**$25,769.77**

2 ONE PIPE GRAVITY

RISERS & MAINS (½ BUILDING)

Pipe		
40'	5"	$ 96.32
35'	4"	55.19
50'	3½"	66.55
50'	3"	50.05
60'	2½"	45.90
300'	2"	117.27
400'	1½"	146.68
380'	1¼"	117.08
320'	1"	74.69
570'	¾"	93.25
Elbows		
3	4"	$ 9.24
8	3"	13.52
4	3x2½"	7.68
38	2"	26.60
15	2x1½"	10.50
6	1¼"	1.68
15	1"	3.30
342	¾"	61.56
Tees		
1	4x2"	$14.31
2	4x2x3½"	
1	3½x3"	22.14
3	3½x2"	
2	3½x3x3"	
1	3x3x2½"	4.78
1	3x2x2½"	
2	2½x2"	12.64
2	2½x2x2"	
4	2½x¾x2"	
4	2x2"	12.09
4	2x¾x2"	
4	2x¾x1½"	
1	2x1¼x1¼"	
19	1½x¾"	25.46
19	1½x¾x1¼"	
15	1¼x¾"	15.60
15	1¼x¾x1"	
15	1x¾"	4.35
1	1" F & T trap	$ 17.25
114	Rad. valves	399.08
114	Air vents	123.22
½ Building		1647.98
Total Building		**$3295.96**

STEAM SYSTEM: 3 ONE PIPE H

BOILER ROOM

1	10330 EDR boiler	$2671.00
1	oil burner	4300.00
1	cond. pump 8000	300.00
1	low water cut off and feed valve	63.39
2	2½" gate valves	49.80
2	2" gate valves	30.68
3	1" gate valves	18.96
1	swing check	21.64
1	air eliminator	17.00
Pipe		
12'	8"	41.00
4'	5"	12.00
8'	4"	15.00
10'	2½"	7.60
4'	2"	2.50
30'	1"	7.00
Elbows		
1	8"	29.21
1	8 x 4"	36.29
2	5"	27.44
4	2½"	4.48
2	2"	1.28
4	1"	0.88
Tees		
2	8 x 5"	41.56
1	4 x 2½"	4.77
1	2½ x 2½ x 1"	1.42
1	4 x 4 x 1"	4.77
4	1"	1.16
Boiler room total		**$7710.83**

MATERIAL

Mains and risers	$3295.96
Boiler room	7710.83
Convectors	5600.00
Covering	700.00

LABOR

Mains	11 days	
38 risers	13	
114 conv.	8	
Boiler room	10	
	42 days -	3360.00
Total		**$20,666.79**

19½% less than the two pipe vacuum steam system

RISERS & MAINS (½ BUILDING)

Pipe		
80'	4"	$126.15
200'	2½"	143.00
200'	2"	98.18
50'	1½"	18.38
540'	1¼"	166.37
600'	1"	140.04
700'	½"	77.00
Elbows		
5	2½"	5.60
4	2"	2.56
40	1¼"	12.40
44	1"	9.68
700	½"	100.80
Tees		
4 2 2	2½ x 1¼" 2½ x 1" 2½ x 1 x 2"	11.36
2 2 2	2 x 1¼" 2 x 1" 2 x 1¼ x 1½"	5.16
2	1½ x 1¼ x 1"	1.34
2 54	1½ x 1 x 1" 1¼ x ½"	29.12
60	1 x ½"	17.40
Supply monoflow fittings	114	195.82
Rad. valves	114	336.30
½ Building		1496.66
Total Building		**$2993.32**

ONE PIPE HOT WATER SYSTEM:

S & MAINS (½ BUILDING)

4″	$126.15
2½″	143.00
2″	98.18
1½″	18.38
1¼″	166.37
1″	140.04
½″	77.00
2½″	5.60
2″	2.56
1¼″	12.40
1″	9.68
½″	100.80
2½ x 1¼″ 2½ x 1″ 2½ x 1 x 2″	11.36
2 x 1¼″ 2 x 1″ 2 x 1¼ x 1½″	5.16
1½ x 1¼ x 1″	1.34
1½ x 1 x 1″ 1¼ x ½″	29.12
1 x ½″	17.40
y monoflow fittings 114	195.82
alves 114	336.30
iding	1496.66
Building	**$2993.32**

BOILER ROOM

1 10330 EDR boiler	$2671.00
1 oil burner	4300.00
2 booster pumps	731.80
4 100 gal. ASME valves	490.88
2 ¾″ gate valves	10.64
4 tank fittings	33.00
4 2½″ flow control valves	48.00
7 2½″ gate valves	174.30
1 ASME relief valve	39.00
1 pressure reducing valve	8.81
2 4″ plugs	1.76
1 1¼″ plug	0.11
2 2½″ caps	1.58
Pipe	
10′ 4″	15.77
20′ 2½″	15.30
10′ 2″	4.91
10′ 1½″	3.67
10′ 1¼″	3.08
Elbows	
3 4″	9.24
4 2½″	4.48
1 1½″	.52
1 1¼″	.31
5 ¾″	.90
Tees	
1 4 x 4 x 1½″	4.77
4 4 x 2½″	19.08
4 2½ x 2½″	5.68
6 1¼ x ¾″	3.12
Boiler room total	**$8601.71**

MATERIAL

Mains and risers	$2993.32
Boiler room	8601.71
Convectors	6160.00
Covering	500.00

LABOR

Mains	10 days	
38 risers	10	
114 conv.	12	
Boiler room	8	
	40 days –	3200.00
Total		**$21,455.03**

16½% less than the two pipe vacuum steam system

RECOMMENDATIONS

Any new design which is at least as good as that now used and costs less, has been recommended. In many cases this policy has resulted in the recommendation of several different designs, which should be considered as alternates. It has neither been thought necessary nor even advisable to select the one best design from among these alternative recommendations. However, in some cases, some of the less important of the recommended designs have been omitted from the following list, in the interests of brevity.

Recommendations are divided into immediate and future. In the latter category are placed all recommendations which involve changes in the building code or other laws, or in union regulations, or which require the approval of the Board of Standards and Appeals.

As previously noted, cost savings are more readily provable in construction than they are in planning. Thus, the most significant among the following recommendations are those pertaining to construction. Unfortunately, it was not possible within the limits of the present study to carry the planning proposals to the stage where accurate cost savings could be established, as was done for the construction proposals.

Plan Studies - Immediate

Use regular column spacing, which saves money with any type of construction. In order to make this possible, the present rigid requirements for room sizes should be somewhat relaxed so that the architect can have some flexibility in planning, and columns should be permitted to project a few inches into the room provided that they do not seriously interfere with the furniture arrangement. Estimated saving 2-3% of total construction cost.

Use skip-stop elevators, with one elevator stop at every third floor. This would save two-thirds of the present cost of elevator doors, frames, signals and switches, and yet no tenant would have to walk more than one floor. Estimated saving $150 per door omitted or about $8 per dwelling unit.

Use the exterior-corridor scheme, combined with skip-stop elevators. Public corridors thus occur only every third floor, all apartments have through-ventilation, and no mechanical ventilation is required. Estimated saving 1% of total construction cost.

Eliminate basements; put tenant storage, laundry, and other functions now located in the basement, on the ground floor. This would save a considerable amount of excavation and foundation work which is more costly than above-ground construction. On some of the buildings in each project it is recommended that the savings from the elimination of the basement be devoted to improved livability, by leaving the remainder of the ground floor open. This would form useful covered recreation space and, by permitting view through building at ground level, would mitigate the "walled-in" feeling often experienced in projects of high-rise buildings.

Consider the use of the living room for sleeping in at least some portion (perhaps 25%) of the total number of dwelling units. No one claims that this is the most desirable living arrangement but since many middle-income families have to live this way, it does not seem unreasonable that tenants of publicly supported housing should too. The living room intended for sleeping should be enlarged and provided with an extra closet and space for a dresser. The resulting savings are substantial — in the order of $1000 per dwelling unit; if done for all dwelling units, the saving would be about 8% of the total construction cost. Design for complete distribution of apartment types in a single building. This simplifies site planning and makes possible small one-building projects.

Plan Studies - Future

Use 7'-6" ceiling height instead of 8'-0". This would gain an entire story in 15 stories, without reducing livability in any respect. It is believed that the lower ceiling would result in more pleasing room proportions and would make the small rooms and windows appear to be larger than they do now. Building Code and Multiple Dwelling Law would have to be revised to permit ceiling lower than 8'-0". Estimated saving 2-3% of total construction cost.

Structure - Immediate

Use six-story non-fireproof construction wherever conditions permit, such as where land values are low, or in combination with high-rise buildings. In the latter case, improvement in scale and better transition to neighboring building heights would result. The wide use of this type of construction for private middle-income housing is evidence of its economy and practicality. The admitted deficiencies can be largely eliminated or at least ameliorated by proper design. Estimated saving 10% of total construction cost.

Use light-steel framing with regular column spacing to the maximum height now permitted by code, which is 100 feet or about 11 stories. Since there is no apparent justification for this height limitation, efforts should be made to have the code changed to permit this type of construction to be used on buildings of any height. Estimated saving may be as much as 2-3% of total construction cost.

Use lift-slab construction. Plans for New York's first lift-slab building have recently been approved by the Building Department. However, this construction has been extensively used in New Jersey and Connecticut and many other places throughout the country and also in Canada and Mexico. To secure the maximum economy inherent in the system buildings must be designed from the outset for lift-slab construction. The most advantageous design for public housing consists of regular column spacing, the use of only two columns across the narrow dimension of the building instead of the usual four, and cantilevered floor slabs of light-aggregate concrete. Based on this design and a height of 14 to 18 stories (8'-1" floor-to-floor), the estimated saving would be 4-6% per square foot cost of floor slab in place, including the structural frame.

Structure - Future

Consider the use of precast concrete box-frame construction. This system of construction consists of casting structural wall and floor slabs on the ground and erecting them by crane; there are no columns or beams. Although there has not yet been sufficient experience with this type of construction in this country to establish accurate costs, there is strong evidence that it will prove to be very economical. In order to secure the maximum benefit from this type of construction, the Building Code should be revised.

Exterior - Immediate

Insulate the present wall construction with the right combination of insulating and back-up materials to arrive at a wall which costs less to install and will save a substantial proportion of the heating cost throughout the life of the building. For example, a cavity wall consisting of 4 inch brick exterior and 3 inch Insulrock interior plastered directly, and with the cavity filled with expanded polystyrene rigid foam insulation costs 2 cents per square foot less than the present exterior wall in place ($2.61 vs. $2.63) and represents a saving of 17 cents per square foot of net exterior wall in reduced cost of the heating installation due to reduced heat losses ($.13 vs. $.30); the net cost of the insulated wall is thus 19 cents per square foot less than that of the present wall ($2.74 vs. $2.93), and it will save 88 cents per square foot of net exterior wall in fuel costs over the fifty-year life assumed for the building ($.72 vs. $1.60). This recommendation covers the insulation of the net (solid) wall which constitutes approximately 75% of the gross exterior wall on most public housing projects.

Considering the benefits of wall insulation spread over the gross exterior wall we find that the entire wall (net wall: as per the above paragraph; window wall: DSB glass in standard D. H. aluminum frames) costs 2 cents per square foot less than the present exterior wall in place ($2.59 vs. $2.61) and represents a saving of 12 cents per square foot of gross exterior wall in reduced cost of the heating plant installation due to reduced heat losses ($.85 vs. $.97); the net cost of the insulated wall is thus 14 cents per square foot less than that of the present exterior wall ($3.44 vs. $3.58), and it will continue to save 45 cents per square foot of gross exterior wall in fuel costs over the fifty-year life assumed for the building ($4.55 vs. $5.00).

Exterior - Future

Use precast concrete sandwich panels. These wall-size panels with windows cast in place have been used for many buildings during the last ten years. However, they have not as yet been used in New York City, and therefore the approval of the Board of Standards and Appeals would have to be obtained. This type of construction can easily meet the required two-hour fire rating. This type of panel with a broomed exterior finish resembling limestone and a smooth trowelled interior finish which needs only to be painted, can be erected for the same cost as the present wall (including cost of heating installation per square foot of net exterior wall in place), but it saves 61% of the wall thickness and will save 70 cents per square foot of net wall area in heating cost over a fifty-year period.

Develop a low-cost insulated metal curtain wall panel. Such a panel could be light in weight, thus reducing the dead load on the frame and foundations; only a few inches thick, thus reducing the overall cubage of the building; well insulated with expanded polystyrene rigid foam, thus reducing the cost of the original heating installation and the cost of fuel for the entire life of the building; large in size, thus permitting the placing of a large area of wall at one time. Metal curtain wall panels can also be developed to meet the present code requirement of two-hour fire resistance, and two examples of this type of construction have been included in the analysis. But if the two-hour requirement were to be reduced, as it now is in many other cities, still greater economies could be obtained from this type of construction.

Interior - Immediate

For partitions within apartments use plaster on gypsum lath (2" thick) or three-ply laminated gypsum board (1½" thick) with taped joints. Other possibilities are exposed concrete block (3") or four-ply laminated gypsum board (2"). Estimated savings, 10-25% of present cost of partitions.

For partitions between apartments use 6" exposed concrete block or four-ply laminated gypsum board. Estimated savings, 10-20% of present cost.

For partitions between apartments and public corridors and between stairs and elevators and public corridors, use exposed concrete block, cement-faced concrete block, or concrete block with sprayed-on enamel finish. Estimated savings, 40-60% of present cost.

For finish flooring in public corridors use vinyl-asbestos tile instead of asphalt tile. The higher first cost will be amortized in five years by the saving in maintenance.

For finish flooring in building lobbies use vinyl tile instead of quarry tile. Estimated saving, 65% of present cost.

For ceiling finish, call for alternate bids on the following: (a) grinding concrete smooth, (b) applying ⅛" thincote plaster, (c) applying stipple-textured masonry paint. Costs of these three methods are approximately equal: Alternate bidding will take advantage of any local or temporary variance.

For bathroom walls around the tub, instead of ceramic tile, use cement-faced concrete block or sprayed enamel on concrete block or on plaster. Estimated savings, 40-60% of present cost.

For bathroom floors use asphalt tile instead of ceramic tile. Estimated saving, 90% of present cost.

Mechanical - Immediate

Use above-floor bath tub and toilet. Higher cost of these fixtures is offset by savings resulting from not having to cut through the floor construction and by the improved appearance and privacy resulting from no soil pipes exposed on bathroom ceilings. Estimated saving, $25.00 per bathroom.

Use 4'-6" bath tub instead of 5'-0". This permits reducing the width of the bathroom by 6" with no reduction in livability. Estimated saving, $35.00 per bathroom.

Use one-pipe mono-flow hot water heating system instead of the two-pipe vacuum steam system now used. Estimated saving, 16% of present heating system cost.

Mechanical - Future

Use copper tubing with soldered joints for both supplies and waste and vent piping. This is now prohibited by the city code, although permitted by the state code. Estimated saving, 10% of roughing cost.

Use loop-venting instead of individual fixture venting. This is now prohibited by the city code, although permitted by the state code. Estimated saving, $22.00 per bathroom.

Use prefabricated plumbing roughing. This is a question of obtaining approval of the local plumbers union. It has been done in a number of other cities. Estimated savings, 10% of roughing cost.

Appendix

Building Cost Indexes

Unless otherwise noted, all prices quoted in this report are given as of Spring-Summer 1958 for the New York City Area. The following Building Cost Indexes are given to enable the reader to set up cost comparisons between any of 24 areas or localities, or between periods of time from June 1957 to June 1959. The Cost Indexes for 24 localities for midyear 1957, 1958 and 1959 are published with the permission of E. H. Boeckh and Associates, Washington, D.C.

Cost comparison (with the use of these indexes) are possible between areas, or periods of time within the same area, by dividing the difference between the two index numbers by one of them:

index for area A = 329.8
index for area B = 304.0
(for Brick and Concrete Construction)

Then: costs in area A are approximately 8½ per cent higher than in B.

$$\frac{329.8-304.0}{304.0} = 0.0855$$

And: costs in area B are approximately 8 per cent lower than in A.

$$\frac{329.8-304.0}{329.8} = 0.0789$$

Again, cost comparisons are possible between two periods of time within the same area, by dividing the difference between the two index numbers by one of them:

index for June 1957 = 329.8
index for June 1958 = 242.9
(for New York City Area)

Then: costs for June 1957 are approximately 36 per cent higher than for June 1958.

$$\frac{329.8-242.9}{242.9} = 0.358$$

And: costs for June 1958 are approximately 26 per cent lower than for June 1957.

$$\frac{329.8-242.9}{329.8} = 0.263$$

Building Cost Indexe

June 1, 1957, 1958,

City and Area
Atlanta Area
Boston Area
Buffalo Area
Chicago Area
Cincinnati Area
Cleveland Area
Dallas Area
Denver Area
Detroit Area
Houston, Texas Area
Indianapolis Area
Kansas City Area
Los Angeles Area
Miami-Miami Beach Are
Minneapolis & St. Paul A
New Orleans Area
New York City Area
Philadelphia Area
Phoenix, Ariz. Area
Pittsburgh Area
St. Louis Area
Salt Lake City, Utah Are
San Francisco Area
Seattle Area
Washington, D.C. Area
National Average

Building Cost Indexes

June 1, 1957, 1958, 1959

Construction Type
Apartment Buildings
Brick and Concrete Construction

City and Area	June 1957	June 1958	June 1959
Atlanta Area	246.1	251.8	263.9
Boston Area	301.3	303.7	313.9
Buffalo Area	299.1	309.0	320.5
Chicago Area	304.0	304.9	322.6
Cincinnati Area	293.8	298.7	307.7
Cleveland Area	314.0	317.2	327.7
Dallas Area	262.7	263.6	272.8
Denver Area	286.1	287.3	296.0
Detroit Area	305.3	311.7	329.7
Houston, Texas Area	265.0	263.6	275.8
Indianapolis Area	280.2	286.3	293.4
Kansas City Area	281.2	285.9	295.1
Los Angeles Area	290.6	304.2	317.9
Miami-Miami Beach Area	262.9	270.3	281.0
Minneapolis & St. Paul Area	293.3	299.0	310.9
New Orleans Area	254.4	257.5	267.0
New York City Area	329.8	242.9	369.8
Philadelphia Area	293.3	299.6	321.2
Phoenix, Ariz. Area	284.1	289.3	304.3
Pittsburgh Area	293.0	306.9	322.9
St. Louis Area	295.9	306.2	316.3
Salt Lake City, Utah Area	272.0	275.4	284.2
San Francisco Area	303.5	312.9	320.8
Seattle Area	297.0	306.3	318.6
Washington, D.C. Area	288.3	294.4	305.7
National Average	288.3	294.7	307.6